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FINAL PROGRESS REPORT ON PLASTIC PRIMARY NORTH CAROLINA KAOLINS, METHODS OF THEIR USE, DEVELOPMENT OF VITREOUS BODIES, AND EXPERIMENTS WITH A CONTINUOUS, HIGH-TEMPERATURE, ELECTRIC TUNNEL KILN: PARTS I–VII*

By The Tennessee Valley Authority Ceramic Research Laboratory Staff

I, NOTES ON A YEAR'S TESTING OF PLASTIC-TYPE NORTH CAROLINA PRIMARY KAOLINS

By R. E. Gould and A. J. Hedquist

Abstract

Data are presented covering twelve months of tests on the commercially refined plastic North Carolina kaolins. Both clays had constant physical properties. Chemical analyses and ceramic laboratory tests show that the commercially refined kaolins are more plastic, stronger, and better than those which were refined in the laboratory and previously recorded. Treatment in a vacuum pug mill was necessary to develop the maximum strength and plasticity of the kaolins. The modulus of rupture, both dry and fired, is quite high for a primary kaolin, and the fired color is good.

I. Introduction

Certain types of vitreous whiteware are still dependent upon primary china clays. The secondary china clays have not been successfully substituted for primary china clays in vitreous ware. English china clays are primary,[1] and there are many types, each differing from the others chiefly in plasticity, dry strength, drying properties, dried and fired shrinkage, fired color, and absorption.

Part III of Progress Report No. 1 recorded experiments on the North Carolina primary kaolins to answer three main questions,[2] *viz.*, (1) Do North Carolina kaolins exist in tonnages great enough to permit extensive use over long periods of time? (2) Can a kaolin of constant quality and good physical properties be made from the crude material at a price permissible in the whiteware industry? (3) Can this kaolin be used successfully in vitreous bodies, and will these bodies have correct shrinkage, freedom from twisting and cracking, and good color if the N. C. kaolin is used with some more plastic material such as Florida kaolin?

These questions were examined because it was believed that the N. C. kaolins were extremely limited in extent and variable in properties from one deposit to another. The kaolins were known to be of the "lean" variety, associated in the deposits with a large amount of mica, quartz, and feldspar, but they were also known to have good firing properties, to be practically free from iron and titanium, and they could be dried and fired without excessive warpage.

The preliminary investigation disclosed that (1) sufficient tonnage of crude material is available to warrant serious work; (2) proper beneficiation of the crude material yields a plastic material with a desirable drying and firing behavior and fired color; and (3) the kaolins thus produced give every indication of being suitable for use in vitreous whiteware.

II. Present Investigation

Two companies are now commercially refining the N. C. clays, and over a period of a year they have produced and sold into vitreous ceramic-ware production a considerable amount of the clay. The production of a primary clay in America is definitely beyond the trial stage.

Investigations were made to answer the following questions: (1) Are the kaolins produced constant in quality? (2) Do they have good plasticity and working properties? (3) Is it possible to substitute one kaolin for the other? (4) Can bodies constant in quality be made with these kaolins as the chief plastic constituent? (5) How should these kaolins be handled in body preparation to make the bodies practical?

III. Testing the Kaolins

The methods of testing the kaolins were those used in the average ceramic-production laboratory with special emphasis on possible variations of plasticity, dry strength, drying shrinkage, and firing behavior, properties which are useful in predicting the behavior of the materials in bodies.

Sufficient quantities from different production runs of these two companies were tested and used over a period of a year so that the results may be regarded as practical.

The kaolins tested represent two varieties which differ in the extent of refining. Clay A has a percentage

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* Presented at the Forty-First Annual Meeting, American Ceramic Society, Chicago, Ill., April 19, 1939 (White Wares Division). Received January 19, 1939.

[1] T. A. Klinefelter and W. W. Meyer, "Properties of Some American Kaolins and a Comparison with English China Clays," *Jour. Amer. Ceram. Soc.*, **18** [6] 163–69 (1935).

[2] Tennessee Valley Authority Ceramic Laboratory Staff, "Progress Report on Occurrence and Refining of Some Tennessee Valley Primary Kaolins, Their Use in Vitreous Ceramic Whiteware Bodies, and Results of Experiments Run to Develop a Modified Type of Vitreous Translucent Dinnerware Made from All-American Materials, Parts I–VII," *ibid.*, **20** [6] 175–214 (1937).

of fine feldspar and quartz with the kaolin; clay B is practically free from quartz and is low in mica and feldspar. Clay A, because of the quartz and feldspar, is similar to some of the English kaolins in firing behavior; clay B, because of its greater-than-average purity, is not so easily vitrified.

TABLE I

AVERAGE ANALYSES OF CLAYS A AND B*

	(A) (%)	(B) (%)
Ignition loss	11.41	13.28
SiO_2	52.50	46.18
Fe_2O_3	0.84	0.57
Al_2O_3	32.98	38.38
TiO_2	0.03	0.04
CaO	0.15	0.37
MgO	Trace	0.42
K_2O	2.06	0.58
Na_2O	0.03	0.10
	100.00	99.92
Calculated rational analysis		
Clay substance	78.06	91.7
Feldspar and mica	13.38	7.2
Quartz	8.56	0
Free alumina (Al_2O_3)	0	1.1
	100.00	100.0

* For a new analysis of clay (A) made in June, 1939, see this issue, p. 245.

The free alumina in clay B is shown in the calculated rational analysis (Table I). It is thought to occur as the mineral, gibbsite ($Al_2O_3 \cdot 3H_2O$),* which apparently is present in the N. C. crudes. The presence of this extra alumina in excess of theoretical kaolinite is thought to be an actual advantage, although compensation must be made for its extra refractoriness when it is substituted for less refractory English china clays.

Table II gives the average results on the physical properties of the two clays.

The dry strengths obtained on hand-wedged material are somewhat higher than those for the average English clays (Klinefelter, Meyer, and Vachuska[3] found the values for 15 English china clays to be between 30 and 140 lb. per sq. in.).

The values obtained with 50% flint pugged under vacuum seem to be quite high and indicative of one good characteristic of the N. C. clays, *viz.*, an improvement in strength and working properties when passed through the vacuum pug mill. This same statement holds true for plasticity. There is apparently an enormous increase in the plasticity of the material pugged under vacuum over the hand-wedged material,

* X-ray determinations run by Irma Rhode, supervised by Paul F. Kerr, Columbia University, 1936.

[3] T. A. Klinefelter, W. W. Meyer, and E. J. Vachuska, "Some Properties of English China Clays," *Jour. Amer. Ceram. Soc.*, **16** [6] 269–76 (1933).

TABLE II

PHYSICAL PROPERTIES OF CLAYS A AND B

(a) 100% clay (hand-wedged)

	(A)	(B)
Plasticity	Good	Good
Water of plasticity (%)	38.6	37.5
Drying shrinkage (%)	4.9	4.5
Modulus of rupture (lb./in.²)	110	150
Fired shrinkage (cone 13) (%)	12	10.3
Absorption (cone 13) (%)	4.5	10.0
Drying behavior	Very good	Very good
Fired color	Good white	Good white

(b) 50% clay, 50% ground flint (data obtained on extruded round bars pugged under vacuum of 27 in. Hg)

	(A)	(B)
Plasticity	Good	Very good
Water of plasticity (%)	26.7	24.65
Drying shrinkage (%)	5.5	4.7
Modulus of rupture (lb./in.²)	196	292
Drying behavior	Very good	Very good
Fired color	Good white	Good white

FIRED DATA

(A)				(B)			
Cone No.	Shrinkage (%)	Absorption (%)	Modulus of rupture (lb./in.²)	Cone No.	Shrinkage (%)	Absorption (%)	Modulus of rupture (lb./in.²)
7	2.7	14.9	2800	7	1.8	18.0	2430
9	4.8	12.2	3750	9	1.9	17.6	2540
11	5.0	8.75	4400	11	2.8	14.5	3100
12	5.2	7.8	4670	12	3.3	13.6	3800
13	5.6	6.2	4870	13	3.5	13.0	4500

(c) Comparative grain sizes of N. C. kaolins (A) and (B) and average English china clay (C)*

Clay	Base exchange capacity (m.e.)	10μ (%)	10–5μ (%)	5–2μ (%)	2–1μ (%)	1–0.5μ (%)	0.5–0.25μ (%)	0.25–0.125μ (%)	0.125–0.0625μ (%)	0.0625μ (%)
(A)	5.58	15.19	29.91	15.81	6.59	4.59	18.95	6.44	1.49	1.03
(B)	5.58	12.48	21.09	19.37	11.26	7.20	15.92	9.64	1.72	1.32
(C)	2.9	28.7	22.8	17.8	10.6	6.2	10.0	1.9	1.3	0.7

* Determined by R. H. Bray, Univ. of Illinois, February, 1938.
m.e. = milliequivalent.
μ = micron.

and this increase in plasticity seems to be much greater than that of the English china clay.

Data on the 50% flint-clay mixtures, fired alike, show that the two clays differ in shrinkage, absorption, and modulus of rupture. The chemical analyses of the clays give a possible explanation; feldspar would increase the shrinkage, decrease the absorption, and increase the modulus of rupture. These data, contrasted with English china clay,[3] indicate that, for a given degree of firing, the strength of the N. C. kaolins is greater than that of English china clays.

The average of the grain sizes contrasted with that of a typical English clay is similar.

One noticeable difference between the N. C. kaolins and the average English china clay (as well as the secondary clays of Georgia and Florida) is the drying behavior of the hand-wedged and pugged specimens, which in the case of the N. C. clays, is extremely good; the others are very tender. Another property noted in the firing trials is the tendency of the specimens to remain straight and to show no signs of absorbing strains.

IV. Constancy in Properties

The quality of the clays, as received, has been constant. The commercially refined products are greatly improved in all respects over those which were refined in the laboratory. Constancy in quality can not be overemphasized because variations in the physical properties of clays will result in variable bodies. These variations occurring in most clays are traceable to a lack of control in their beneficiation process rather than to variations in the deposits themselves.

NOTE: The clay variations are the basic reason for the highly skilled hand labor in the ceramic industry. This condition is aggravated further by the difficulty of checking and correcting the variations as they occur in the average plant. If the ceramist looks too closely at the original cost of the clay and too lightly accepts variations in physical properties, the inevitable result will be losses or extra costs in procedure which far exceed small differences in prices of the raw materials. The place to overcome variations in raw materials is at the mine and refinery and not in the ceramic plant. This can be accomplished only by close technical control and research.

V. Conclusions

Testing commercially produced plastic N. C. kaolins indicates that (1) these clays are produced with surprisingly constant physical properties; (2) the two commercially refined clays differ chiefly in the percentages of feldspar and quartz, which in turn are traceable to the differences in refining processes; (3) the plasticity of the two clays is very good, differing from the English china clays in type of plasticity; (4) the drying properties and dry strength are of a superior quality; (5) in substituting one clay for the other or either clay for the average English material, the chemical and rational analyses should be considered closely to compensate for differences in shrinkage, absorption, and strength; and (6) the color of the fired kaolins is equal to or better than that of any kaolin tested.

COMPARATIVE STUDY OF ACID- AND BASE-BINDING CAPACITIES AND VISCOSITY RELATIONS IN (A) AND (B) CLAYS—SUPPLEMENT TO PART I*

BY E. C. HENRY

I. Experimental Methods

Samples of both (A) and (B) clays were electrodialyzed in Mattson-type cells[5] and were dried in air. Suspensions for testing were prepared by dropping the air-dried clay into Pyrex-brand flasks and test tubes containing various electrolyte solutions, the concentration employed being 50 grams of clay to 100 cc. of solution. The containers were stoppered, placed in a shaker, and agitated for about 3 hours. They were shaken again 36 hours later, and the viscosity and the p_H of the slips were measured.

Hydrogen-electrode p_H measurements were made in Bailey-type electrode vessels.[6] The flow behavior was determined with a calibrated Stormer viscosimeter and was expressed as "apparent viscosity." These values represent the viscosity that a Newtonian liquid (one with a zero yield value) would have if it had required the same time as did the clay slip for 100 revolutions of the viscosimeter spindle when activated by the same weight.

The ultimate p_H is the p_H of the electrodialyzed clay in water. The p_H of exchange neutrality is the p_H of the point of intersection of the titration curves for electrodialyzed clay in distilled water and for the same clay in a solution of a neutral salt (in this case, $^1/_2$ N sodium chloride). The combining or saturation capacity is expressed as the number of milliequivalents* of base required to neutralize 100 grams of electrodialyzed clay.

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* Shortly after this Report was completed, a fine article by E. C. Henry and N. W. Taylor[4] was published, which gave the results of studies of the relationship between the chemical and physical behavior of clay slips. The old type of N. C. kaolin was included in this study. Dr. Henry kindly agreed to make similar tests on the new N. C. kaolins, (A) and (B), and the following report was submitted by him.

The authors wish to thank Dr. Henry for his contribution to these studies.

[4] E. C. Henry and N. W. Taylor, "Acid- and Base-Binding Capacities and Viscosity Relations in Certain Whiteware Clays," *Jour. Amer. Ceram. Soc.*, **21** [5] 165–75 (1938).

[5] S. E. Mattson, "Electrodialysis of Colloidal Soil Material and Exchangeable Bases," *Jour. Agric. Research*, **33**, 553–67 (1926).

[6] E. H. Bailey, "Effect of Air Drying on Hydrogen-Ion Concentration of Soils of the United States and Canada," *U. S. Dept. Agric. Tech. Bull.*, No. 291 (1932).

* A milliequivalent is $^1/_{1000}$ gram equivalent weight; the abbreviation, m.e., is used in this paper.

II. Experimental Results

(1) Clay (A) Electrodialyzed

The ultimate p_H of clay (A) was 4.6 (see Fig. 1). The base-combining capacity of the clay was 2.7 m.e. at p_H 7 and 3.2 m.e. at p_H 8. The p_H of exchange neutrality was 3.2, requiring the addition of 1.8 m.e. of HCl to the hydrogen clay.

The viscosity of this clay when electrodialyzed (Fig. 2) was lower at every point than it was with electrodialyzed clay (B). In water alone, the viscosity was

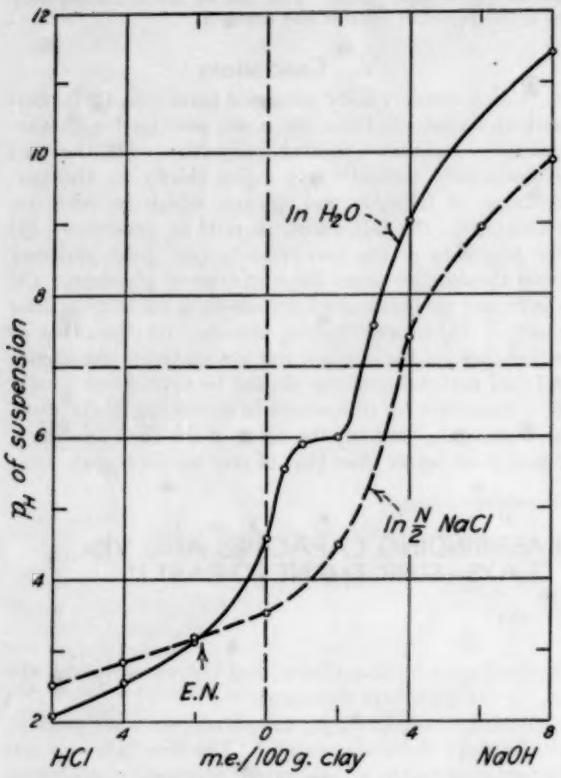

FIG. 1.—Clay (A) electrodialyzed.

114 centipoises.* This was lowered to 22 centipoises by ½ m.e. of NaOH, to 10 centipoises by 3 m.e. of NaOH, and to 8 centipoises by 8 m.e. of NaOH.

(2) Clay (B) Electrodialyzed

The ultimate p_H of clay (B) was 4.5. Its base-combining capacity at p_H 7 was 4.1, and at p_H 8, it was 5 m.e. of NaOH per 100 grams of air-dried clay. The p_H of exchange neutrality, shown by the titration curves of Fig. 3, was 3.4, corresponding to the addition of 2.7 m.e. of HCl per 100 grams of clay.

The effect of electrolyte content on the apparent viscosity is shown in Fig. 4. The viscosity of the electrodialyzed clay in water was about 1000 centipoises. One-half m.e. of NaOH lowered it to 225, and when 6 m.e. had been added, the viscosity was 10 centipoises.

* The viscosity of water at 20°C is about one centipoise.

(3) The Clays as Received

Figures 5 and 6 show the p_H-viscosity relations of unelectrodialyzed (A) and (B) clays respectively, curve (50) with 50 grams and curve (100) with 100 grams of clay per 100 cc. of liquid.

In distilled water, the p_H of clay (B) was 7.8; its viscosity was 14 centipoises with 50 grams of clay per 100 cc. and 88 centipoises with 100 grams. The minimum viscosities obtainable were 11 and 30 centipoises

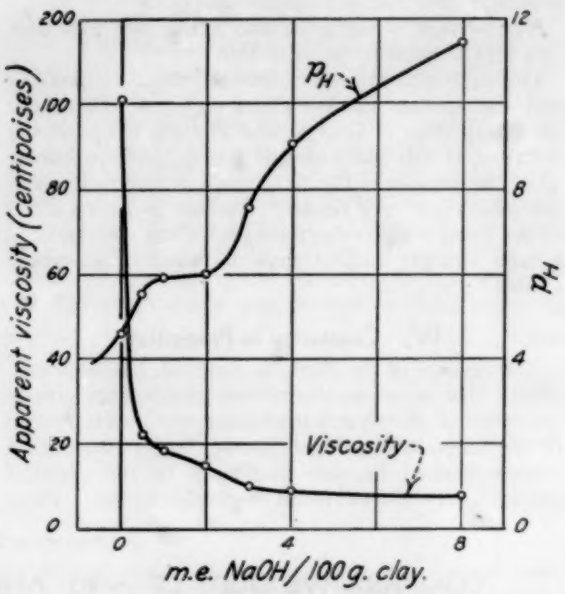

FIG. 2.—Clay (A) electrodialyzed.

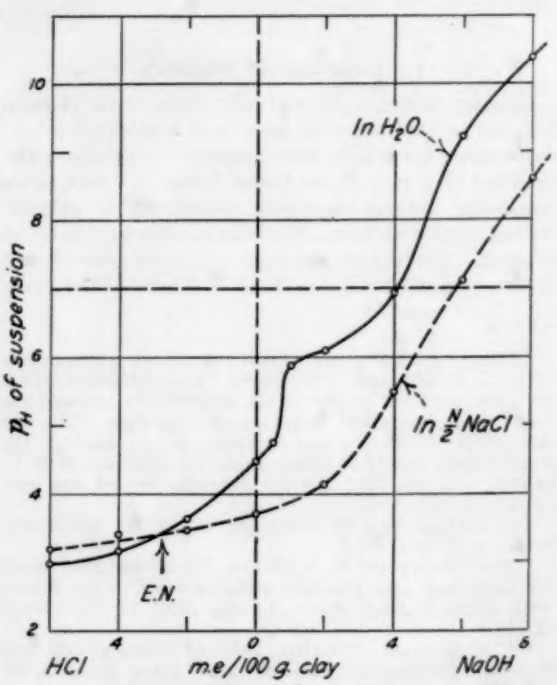

FIG. 3.—Clay (B) electrodialyzed.

respectively at p_H 10 or above. The titration curve had a very small inflection compared to that of clay (A).

Clay (A) in water had a p_H of 5.7; the viscosity was 22 centipoises with 50 grams and more than 1000 centipoises with 100 grams per 100 cc. One-half m.e. of NaOH reduced these to 16 and 490 centipoises, and the minimum viscosities reached were 10 and 24 centipoises.

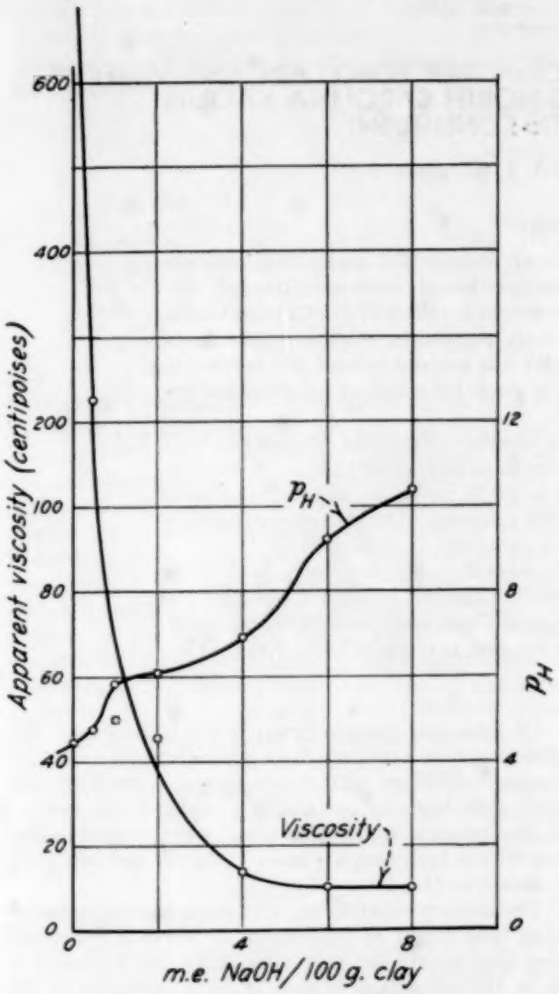

FIG. 4.—Clay (B) electrodialyzed.

III. Interpretation

In comparing the electrodialyzed clays, it was noted that clay (B) had the greater combining capacity and higher viscosity, even at maximum deflocculation. This would lead to the prediction that it might be the finer grained of the two if it is assumed that both are composed of the same clay minerals.

It was interesting, therefore, to find that as received (as marketed) the p_H of clay (B) in distilled water was 3.3 units higher than when electrodialyzed (while clay (A) was but 1.1 unit higher than when electrodialyzed) and that its viscosity in water was lower than that of clay (A). As to the minimum viscosity obtainable at higher concentrations of NaOH, the situation was reversed and became the same as with the electrodialyzed clays, *viz.*, that clay (A) was deflocculated to a lower viscosity than was clay (B).

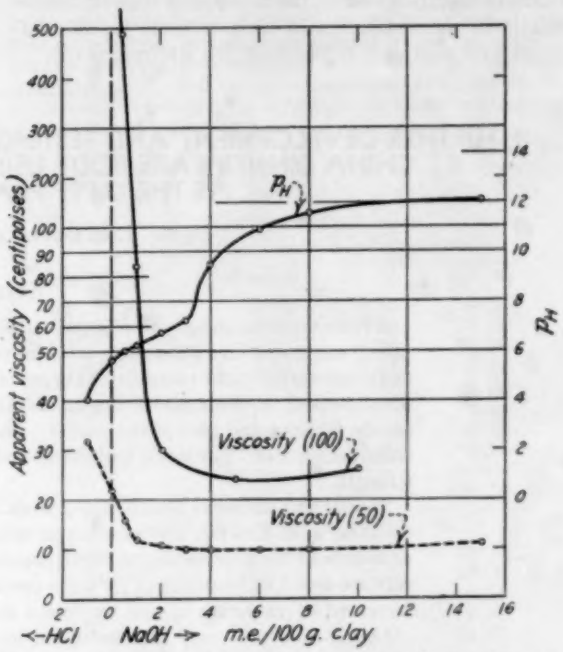

FIG. 5.—Clay (A) as received: curve (50) with 50 grams; curve (100) with 100 grams per 100 cc. liquid.

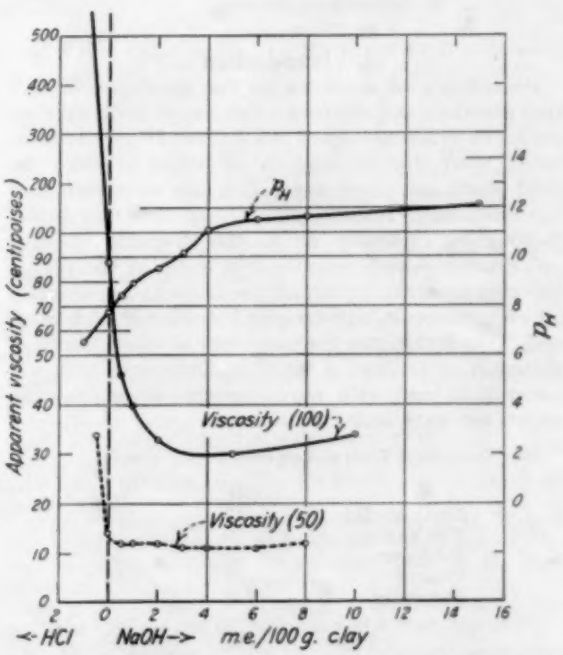

FIG. 6.—Clay (B) as received: curve (50) with 50 grams; curve (100) with 100 grams per 100 cc. liquid.

The initial higher p_H and lower viscosity of clay (B) and also the lack of a strong inflection in its titration curve suggest that the washing processes may have left the clay partly saturated with alkaline salts tending to deflocculate it. By the same reasoning, the high initial viscosity, lower p_H, and sharp inflection in the titration curve of clay (A) lead to the conclusion that it may be relatively unsaturated with base or even partly saturated with acid as it comes from the washing plant.

The result of such accidental or purposeful adjustment seems to have been to make the two clays (as marketed) more alike in the effect of NaOH on viscosity than they were in the "electrolyte-free" or electrodialyzed condition; *e.g.*, both clays reach minimum viscosity on curve (50) at 3 m.e. NaOH and on curve (100) at 5 m.e. NaOH.

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II, FURTHER DEVELOPMENT AND TESTING OF A TRUE PORCELAIN AND VITREOUS CHINA DINNERWARE BODY USING NORTH CAROLINA KAOLIN AS THE CHIEF PLASTIC CONSTITUENT

By R. E. Gould and A. J. Hedquist

Abstract

A body with the composition of clay substance 41, feldspar 16.6, quartz 40.4, and dolomite 2 was tested on a pilot-plant scale for twelve months and results were recorded. The body was varied in the two different types of commercially refined North Carolina kaolin, which formed the main plastic ingredient, and in the pegmatites, which were substituted for the feldspar and part of the quartz. Ball clay was not used because it is harmful to translucency; 12.7% Florida kaolin was added to attain the necessary plasticity and dry strength.

Special emphasis was placed on the working properties to determine whether this body could be worked as fast and as safely as semivitreous or hotel china bodies. It was possible to hold the average dry strength constant to 350 lb. per sq. in., and this modulus of rupture seems to be sufficient for mass-production methods. The plasticity was greatly increased by vacuum pug-mill treatment and by aging two or three days.

One N. C. kaolin may be substituted for the other if proper attention is paid to the chemical analyses and to the adjustment of body shrinkage and absorption requirements. The fired color is white under reducing conditions and light ivory under oxidizing conditions. The translucency is sufficient to enable the ware to compete easily with that imported from Europe.

I. Introduction

Preliminary experiments on the development of a true porcelain and a vitreous china-type body were reported in Progress Report No. I (Part IV).[2] As mentioned there, the development of bodies in which the chief plastic ingredient was N. C. kaolin was undertaken for three basic reasons, *viz.*, (1) to test this kaolin thoroughly, especially as to the desirable physical properties ordinarily found only in bodies high in plastic ball-clay content; (2) to use the body as a severe test for experiments in high-temperature electric kiln firing; and (3) to investigate the possibility of using American materials to produce a vitreous dinnerware that will compete in cost with ware imported from countries with a low wage scale.

First Trials of Two Body Compositions

	No. 1 (%)	No. 2* (%)
N. C. kaolin	40	33
Fla. kaolin	10	10
Feldspar	33	20
Quartz	17	35
Dolomite	0	2
	100	100

* See Progress Report No. I, Part IV, *Jour. Amer. Ceram. Soc.*, **20** [6] 195 (1937).

Of these two compositions, No. 1 is similar to the true porcelain type, which is generally fired under reducing conditions with a low bisque (cone 010) and high glost (cone 14); No. 2 is a modified composition of the American hotel china type,[7] which is fired oxidizing with a high bisque (cones 11 to 12) and low glost (cones 3 to 7).

Preliminary experiments with these bodies indicated that both might be practicable in working properties and fired quality but that composition No. 2 seemed to have the advantage in cost of body, strength of the fired piece, and ease of glaze fit. The firing temperature in each case was cones 13 to 14. This high heat treatment was adopted to facilitate firing tests in electric kilns.

II. Present Investigation

Bodies containing no ball clay and an untried kaolin are so radically different from the usual types that extensive laboratory tests are necessary if practicable conclusions are to be drawn. Laboratory results may be difficult to interpret in terms of the results obtained

[7] R. F. Geller, "Bureau of Standards Investigation of Feldspar, Second Progress Report," *ibid.*, **10** [6] 411–34 (1927); p. 423.

in plant production, especially if the conclusions are drawn from a limited number of small-scale experiments. Consequently, a typical body was tested on a pilot-plant scale, and the experimental work was continued long enough to assemble positive data.

Two types of bodies were used, *viz.*, No. (1) feldspar and No. (2) pegmatite.

(1) Feldspar Bodies

With two commercial-type N. C. kaolins, the body formula chosen was clay substance 41.0, feldspar 16.6, quartz 40.4, and dolomite 2. With clays (A) and (B), this formula is as follows:

	Body formula	
	No. 1 (%)	No. 2 (%)
N. C. kaolin (A)	36.8	
N. C. kaolin (B)		31.3
Fla. kaolin	12.7	12.7
Potash feldspar	12.5	18.0
Flint	36.0	36.0
Dolomite	2.0	2.0
	100.0	100.0

In these formulas, the substitution of one clay for the other required attention not only to the rational analyses but to the all-important properties of shrinkage and absorption at definite temperatures. A strict substitution on the chemical-analysis basis alone would require the addition of flint as well as feldspar to the body built around clay (B). In this case, however, the shrinkage was somewhat lower, and the body required a further alteration of feldspar content at the expense of the calculated flint. Using the general formula, the bodies were tested under semicommercial conditions with a definite quality and product in view and with sufficient quantities to vary the types of kaolin and feldspar used. These variations were the substitution of one clay for the other and of pegmatites for the feldspar and part of the quartz. The general scheme was to see if the working properties of the body as well as of the fired ware would conform to a general standard.

(2) Pegmatite Bodies

The materials used were kaolin (see Part I, p. 206, for the chemical and rational analyses), feldspar, and pegmatites No. 1 and No. 2. The pegmatites are easily available in large quantities, and the calculated mineral compositions show them to be mixtures of potash and soda feldspars in amounts approximating 50% of each.

NOTE: The experiments with pegmatites were made because the tonnage of No. 1 feldspar in the United States is not unlimited.[8] Watts[9] has stated that the ceramic industry must look to the pegmatites and graphic granites as a source of this feldspar. The use of soda *vs.* potash feldspars and the properties of the bodies produced have been discussed by many writers.[10] Pegmatites have been used successfully in Europe for many years.[11] The American ceramic industry has never taken kindly to this idea unless the use of Cornwall stone, which was formerly quite extensive, may be classified under this heading.[12]

Two facts appear to justify these experiments, *viz.*, (1) feldspar and quartz are introduced separately into practically all ceramic bodies and the use of a No. 1 feldspar considerably raises the cost, and (2) the chemical control of feldspars[13] has advanced rapidly to the point where it is now an accepted procedure to substitute one feldspar for another, keeping the quality and properties of any one feldspar constant.[13] This same chemical control may be substituted easily for a mixture of feldspar and quartz occurring in the form of pegmatites.

TABLE I

Chemical analysis

		Pegmatite	
	Feldspar	No. (1)	No. (2)
Ignition loss	0.66	0.29	0.31
SiO_2	67.00	74.04	72.50
Al_2O_3	18.37	15.64	16.76
Fe_2O_3	0.09	0.16	0.14
CaO	0.34	0.80	1.28
MgO	Trace	Trace	Trace
K_2O	11.11	5.54	5.13
Na_2O	2.35	3.78	3.98
	99.92	100.25	100.10

Calculated mineral composition

Potash feldspar	65.72	32.7	30.36
Soda feldspar	19.97	32.0	33.64
Lime feldspar	1.67	3.9	6.34
Kaolin	4.62	4.9	5.85
Quartz	7.84	26.9	24.27
	99.82	100.4	100.46

Pegmatite bodies

	(1)	(2)	(3)	(4)
Kaolin (A)	36.8	36.80		
Kaolin (B)			31.3	31.3
Fla. kaolin	11.8	11.68	11.4	11.2
Pegmatite No. 1	18.3		26.4	
Pegmatite No. 2		17.85		25.7
Flint	31.1	31.68	28.9	29.8
Dolomite	2.0	2.00	2.0	2.0
	100.0	100.01	100.0	100.0

[8] A. S. Watts, "Feldspar Supply of the United States," *Trans. Amer. Ceram. Soc.*, **16**, 80–95 (1914).

[9] A. S. Watts, "Graphic Granites as a Source of Feldspar," *ibid.*, **15**, 451–66 (1913).

[10] (*a*) A. S. Watts, "Comparison of Potash and Soda Feldspar Porcelains," *ibid.*, **11**, 179–84 (1909).
(*b*) Edward Schramm, "Effect of Potash and Soda Feldspars in a China Body," *Jour. Amer. Ceram. Soc.*, **10** [12] 1005–1006 (1927).

[11] (*a*) Otto Krause, "Use of Weiherhammer White Pegmatite in Technical Porcelain Bodies," *Sprechsaal*, **65** [45] 807–808 (1932); *Ceram. Abs.*, **12** [2] 68 (1933).
(*b*) Albert Granger and Raymond Keller, Die Industrielle Keramik, p. 34. Julius Springer, 1908.

[12] J. H. Weis and J. E. Boyd, Jr., "Carolina Stone," *Jour. Amer. Ceram. Soc.*, **20** [2] 62–63 (1937); see also footnote 10(*b*).

[13] (*a*) A. J. Monack, L. R. Shardlow, and D. H. Wamsley, "Dielectric Strength of Porcelain: Influence of Firing Temperature," *Jour. Amer. Ceram. Soc.*, **15** [2] 126–29 (1932).
(*b*) J. H. Chilcote, "Influence of Composition of the Feldspar Constituent on Properties of a Porcelain Body," *ibid.*, **17** [7] 203–204 (1934).
(*c*) E. Schramm and F. P. Hall, "Fluxing Effect of Feldspar in Whiteware Bodies," *ibid.*, **19** [6] 159–68 (1936).

III. Production Procedure

In Part I of this Report, the N. C. kaolins were shown to be markedly improved in quality if they were treated in a vacuum pug mill. This treatment was also important if the working properties of the body were to be developed to the maximum. The improvement in working conditions of a body by passing it through a vacuum pug mill is now a generally accepted fact.[14]

The general methods of procedure in the preparation of the bodies were as follows:

Weighing: Formulas were weighed out in 800-lb. batches, keeping all materials on a dry weight basis.

Mixing: The bodies were prepared both by blunging (as is done in the semivitreous industries) and by grinding the entire charge for 3 hours in a ball mill. When the blunging method was used, the dolomite was first ground wet, with approximately 4 times its weight of N. C. kaolin, for 12 hours to insure its being fine enough and wholly dispersed throughout the clay.

Screening: Bodies were screened through 140- and 150-mesh lawns, passed over a strong electromagnet, and filter-pressed to an average of 105 lb. per sq. in., using either a 2-cylinder diaphragm pump or air pressure. This air pressure is higher than the 80 lb. ordinarily used in the whiteware industry. With this type of body, 100 lb. (or even more) were necessary to reduce the water content of the clay leaf to the point where the body would not emerge too soft from the pug mill. In this respect, the N. C. clays seem to be different from the English kaolins. In the pumping, pressure was increased slowly to get a well-filled, homogeneous clay leaf.

Pugging: These bodies were pugged and aged or used directly in some cases.

Casting Scrap: The casting scrap was re-used and introduced into the body as follows: (1) the casting scrap was blunged into a slip at the same specific gravity used in making the fresh body; (2) the viscosity of the casting-scrap slip was measured and adjusted with aluminum chloride to the same viscosity as that of the fresh body slip; and (3) the slip was lawned, passed over the magnet, and introduced into the fresh body slip in the smooth agitator; the amounts introduced were quite high, usually about 15%.

The neutralization of flocculating agents in casting scraps is thought to be a generally known procedure and is mentioned specifically by Bentley.[15] Tests were made on the mixture of the fresh and casting-scrap slips in the smooth agitator and when necessary adjustments were made in viscosity by the addition of more aluminum chloride. After stirring thoroughly for at least 2 hours, the slip was pumped as described. No detrimental effect of the casting scrap was seen; in fact, in the body prepared with the addition of casting scrap, using No. 2 clay deflocculent, there was a noticeable increase in plasticity which may be due to the effect of aluminum chloride on primary N. C. kaolin as noted by Reinecker and George.[16]

Aging: Early experiments showed that if the filter-press leaves were pugged and the body was aged for 3 or 4 days and then re-pugged under vacuum, the plasticity and strength underwent a remarkable increase. Aging beyond this time did not result in enough improvement to justify longer periods. The body from the second pugging was taken directly to the jiggers or it was made into casting slip according to the procedure recorded in Part III (p. 214).

Sample Testing: Samples of the body prepared either for plastic forming or for casting were tested for physical properties. In every case, the work of forming the bodies was done by expert journeymen, workmen whose long experience in the semivitreous industries qualified them to answer the following important questions: (1) Can these bodies be processed as rapidly and cheaply as semivitreous bodies containing high percentages of ball clay? (2) Do these bodies differ in working qualities in an amount sufficient to cause noticeable variation?

Over a twelve-month period, approximately 30 tons of body in seventy-five 800-lb. batches were treated and tested. Table II gives average physical data.

TABLE II*

	(A) Feldspar or pegmatite	(B) Feldspar or pegmatite
Water of plasticity (%)	24	24
Drying shrinkage (%)	5.0	4.9
Modulus of rupture (lb./in.²)	330	360
Firing shrinkage (%)	7.5	7.6
Fired modulus of rupture (lb./in.²)	6900	7100

* Although the physical data indicate that these bodies were essentially equal, there was nevertheless a discernible difference; the workmen reported that bodies made with kaolin (B) were somewhat better in plasticity, jiggering properties, and drying.

The physical data recorded in Table II are based on many trials run under similar conditions. The properties may be varied with body preparation, especially aging, and the fired properties may be varied according to the degree and speed of firing. The data recorded represent the average obtained after correct methods of procedure were determined and standardized; the variations occurring were well within the limits of good laboratory practice.

IV. Process Control

It was hoped to develop a ware which is vitreous and translucent and which may be processed at a relatively low cost. The strength of the fired body should be equal to hotel china, and the color and translucency should approximate those of bone china or belleek. A body of this type is desirable from a manufacturing standpoint, particularly if final costs are within limits which meet competition from countries whose wage scale is low.

Special emphasis therefore was placed upon body control because it is believed that mechanization and

[14] Mayer China Company, "De-Aired and Nonde-Aired Body Compared in Tableware Production," *Ceram. Ind.*, **26** [4] 279–80 (1936); *Ceram. Abs.*, **15** [10] 306 (1936).

[15] J. W. Bentley, "Utilization of Casting Scraps," *Trans. Ceram. Soc.* [England], **36** [3] 75–83 (1936–1937); *Ceram. Abs.*, **16** [10] 307 (1937).

[16] H. P. Reinecker and J. S. George, "Effect of Aluminum Chloride upon Clays," *Jour. Amer. Ceram. Soc.*, **3** [12] 994–96 (1920).

mass-production methods can be used only where variations in the physical properties of the body are no greater than those which can be compensated for in a machine (not by skilled workmanship). If production can not be wholly mechanized, it is hoped that enough of the methods common to semivitreous ware production can be used so that the production per man will permit the manufacture of moderately priced ware.

V. Results

(1) Breakage

Breakage in the green and bisque ware is roughly inversely proportional to variation in the dry modulus of rupture.[17] This breakage is less with proportional increases in dry modulus of rupture, *i.e.*, a greater variation in dry strength is permissible with very strong bodies. This is one of the basic reasons for the use of large amounts of ball clay in semivitreous bodies, and it is not uncommon to find bodies with a strength of 500 to 600 lb. per sq. in. With reasonable care, lower strengths may be used, but the percentage variation from the average must be less. Thus a body with an average modulus of rupture of 100 lb. per sq. in. might be worked successfully, providing the dry strength does not vary more than ±5%; a body of an average of 200 lb. might vary ±10%; one of 300 lb., ±15%; and one of 500 lb., ±20%, without noticeable effect on losses.

It is also known, and unfortunately too frequently disregarded, that dry strength in any given body is materially affected by each detail in the method of body preparation as well as by variations in the raw materials themselves.[18] Clays, in general, are extremely sensitive, and it is easy to imagine many variables occurring in the same body which tend to compensate or to exaggerate each other. An ideal situation would be to have a body of good strength with extremely low variation made from materials of constant quality so that the quality of the whole body could be controlled alone by a standard method of procedure.

The dry modulus of rupture, 350 lb. per sq. in., obtained in this experiment, is believed to be sufficient for fast working by mass-production methods. It is exceptionally high for all-kaolin bodies, and it indicates that ball clays are not absolutely necessary with the N. C. china clays.

[17] F. H. Riddle and J. S. Laird, "Tensile Strength of Porcelain," *Jour. Amer. Ceram. Soc.*, **5** [7] 385–93 (1922).

[18] (*a*) F. H. Riddle and Robert Twells, "Standardization and Plant Control as Applied to Body Making," *ibid.*, **10** [4] 281–91 (1927).

(*b*) Thomas Place, "Quality of Dinnerware Improved by Preventing Defects in the Clay State," *Ceram. Ind.*, **11** [6] 612–14 (1928); *Ceram. Abs.*, **8** [2] 132 (1929).

(2) Translucency and Color

Fired under reducing conditions, these bodies have a high translucency and a good white color. It was formerly believed[2] that reducing conditions were necessary to develop sufficient glass to permit the transmission of a desirable amount of light. Experiments (in Part V, p. 234) have disproved this assumption. It is known now that translucency in bodies of this type can be produced under oxidizing conditions. These have a light ivory color with enough translucency to meet the requirements for medium-priced dinnerware.

In experimenting with the N. C. kaolin bodies, translucency was obtained easily; the introduction of appreciable amounts of secondary clays or ball clays tended to decrease translucency to a marked degree.

Schramm[10(b)] observed that soda feldspar decreased the translucency of a body, and this was also true in the pegmatite bodies. Experiments indicate that a high potash feldspar is best for high translucency. The deduction perhaps was somewhat clouded because the pegmatites, owing to their lack of commercial preparation, were not as free from impurities as they could be with better processing.

(3) Glost Warping

Flatware and hollow ware, fired under oxidizing conditions, were rigid when supported on pins during the glost fire. The test shapes and weights which were used and the comparatively high glost temperature (cones 7 and 8) illustrated this point.

VI. Conclusions

The pilot-plant experimentation with all-kaolin bodies in which commercial N. C. kaolin was the chief plastic constituent indicates that (1) the bodies have plasticity, drying behavior, working properties, and dry strength ample for mechanical mass-production methods; (2) the firing behavior, fired strength, color, and translucency are sufficiently good to fall within the prescribed limits; (3) it is possible to process bodies within close limits of variation if proper attention is given to the method of preparation; (4) these two clays may be substituted successfully, one for the other, if proper attention is given to the differences in chemical analyses and to their respective effects on shrinkage and absorption; (5) there was no apparent difference other than translucency when pegmatites were substituted for feldspar and part of the quartz; and (6) Florida kaolin is an ideal supplement to the N. C. kaolin, and when used in amounts of approximately 10%, it has no detrimental effect upon working properties, color, or translucency.

III, NOTES ON CASTING ALL-KAOLIN BODIES

By A. J. Hedquist, E. Wilson, and R. E. Gould

Abstract

The bodies recorded in Part II were tested to see whether casting could be done quickly and easily and kept under close control. Two deflocculants were used which previously had been found best for bodies made from all-American kaolin, *viz.*, sodium gallate and the commercially prepared No. 2 clay deflocculant. Both dispersing agents were successful, with the No. 2 clay deflocculant slightly better.

One hundred and twenty-five 1/4-ton batches were processed. It was possible to control the casting properties within extremely close limits if the viscosity, specific gravity, and temperature were held at specified values thought to be easily attainable. It was important to have the clay properly prepared before making it into casting slip, and it was especially necessary to have it pugged from the filter press, aged 2 or 3 days, and repugged under vacuum. The casting appeared to be much better than that of the average semivitreous or hotel china bodies commonly found in production. With these dispersing agents, the mold life was much longer than with sodium carbonate and sodium silicate.

I. Introduction

The casting of all-kaolin bodies, similar in composition to those recorded in Part II, at first gave considerable difficulty. Apparently successful methods of casting which produced good results were recorded in Part V (p. 197) of Progress Report No. I.[2] The experiments showed that, for successful working, these bodies require treatment and dispersing agents different from those ordinarily used. Sodium carbonate and sodium silicate were unsuccessful, but sodium tannate, sodium gallate, and a commercially prepared organic clay deflocculant worked very well.

Early experiments indicated that properly prepared casting slips using any of these dispersing agents could be controlled within close limits. With controlled viscosity and specific gravity and reasonably close temperature conditions in the casting room, the bodies cast evenly and quickly with excellent drainage and released from the molds without difficulty. The resulting pieces were strong enough to be handled without more care than is used in production of the average semivitreous body.

The casting was done by a journeyman caster of long experience, and interesting data were obtained by holding constant the physical properties of the casting slip. These experiments were continued over long periods of time and with large batches to determine whether or not the properties of "castability,"* viscosity, specific gravity, and temperature would be constant under conditions similar to those met in actual production.

II. Procedure and Results

The casting slips were prepared with two types of dispersing agents, sodium gallate and the commercially prepared No. 2 clay deflocculant, which is organic in nature. In twelve months, approximately 25 tons of body were made into 125 batches of casting slip. Approximately five tons of body were prepared with the sodium gallate and 20 tons with the No. 2 clay deflocculant.

The reasons for the greater use of the latter deflocculant were that (1) the slip cast somewhat faster than with sodium gallate; (2) the bodies released from the molds easier; (3) a more plastic cast was obtained which facilitated easier cutting of handles, etc.; (4) there was no danger from "soda marking" on the finished piece; (5) the danger of adding too much of the deflocculating agent was minimized, whereas the amount of sodium gallate had to be kept within close limits because of its soda content; and (6) it had a good effect on mold life.

(1) Slip Preparation

In all cases, a successful casting slip required a double pugging with an intervening aging period of at least three days.

It was necessary in each case to agitate the slip gently and continuously and to permit it to come to equilibrium before being used; the minimum time for this was 24 hours. The speed of agitation, within certain limits, is important if the slip is to be kept at its best working properties and the ware is to be free from pinholes.

A porcelain-lined tank, 24 in. inside diameter and 30 in. high, was used with the conventional type of sweep revolving at 30 r.p.m. Both types of casting slips were sensitive to temperature conditions within the laboratory, and the best working properties were obtained if normal shop temperatures were held. This statement applies to all types of bodies and casting slips.

(2) Use of Sodium Gallate as a Dispersing Agent

The preparation of sodium gallate has been recorded by Schramm and Hall,[19] and its use in all-kaolin bodies

* Castability is the time required for a given piece to cast to a given thickness and weight in similar molds, with the same type of draining, easy release from the molds, and quality of ware.

[19] Edward Schramm and F. P. Hall, "Notes on Casting Slip," *Jour. Amer. Ceram. Soc.*, **17** [9] 262–67 (1934).

has been described in Part V (p. 199) of Progress Report No. I.[2]

In these experiments, the specific gravity of the casting slip was best between 1.86 and 1.90, with 1.88 the most satisfactory. At a specific gravity of 1.88 and a temperature of 90°F, the average viscosity was 48 to 50 seconds for 250 cc. to flow from an open-top Marriott tube. With the temperature and specific gravity at these values, the viscosity could be held to ±3 seconds for a period of 2 or 3 weeks. "Castability," draining, release from the molds, and freedom from pinholes and cracks were constant with these values. Difficulties with cracking and sticking to the mold were encountered with a drop in specific gravity below 1.86, and these increased with a further decrease in gravity.

With a temperature drop, the viscosity increased quite rapidly; a drop from 90° to 75°F resulted in an average viscosity increase of about 12 seconds. The casting slip still worked fairly well at this temperature, but it was not as good as when higher temperature conditions were maintained. Because 75° to 80°F is considered to be the normal shop temperature, a heating element for the casting slip would be desirable if sodium gallate were used.

(3) Use of No. 2 Clay Deflocculant as a Dispersing Agent

The specific gravity of the casting slip with this deflocculant was held between 1.80 and 1.83, with the best working conditions at 1.81. Gravities outside of these limits resulted, in one case, in a too-sluggish casting slip with poor draining qualities and, in another instance, in cracking, which increased with a decrease in gravity. Gravities lighter than 1.80 also produced a "short" body which was difficult to cut and trim. With a specific gravity of 1.81 to 1.82 (limits which were closely held) and a temperature of 75° to 80°F, the viscosity was 50 ±2 seconds. An increase in temperature above 85°F caused an apparent loss of ammonia with a resulting increase in viscosity and cracking of the pieces. With temperatures below 60°F, the slip was too sluggish to drain properly.

The average casting time of both slips for a piece of ordinary dinnerware weight was between 4½ and 6 minutes, which was held by close control of the viscosity, temperature, and specific gravity. Three (and sometimes four) casts per day could be made easily from each mold, providing sufficient time were given for drying the mold as is done under normal shop conditions.

NOTE: Because the casting time of these bodies is comparatively short and this time and the properties of the cast apparently do not vary, the use of a conveyer belt in the casting shop is suggested, with a consequent rationalization of the work instead of the usual bench procedure. All molds would travel at a given rate of speed, would be filled at one station, drained at a second, and emptied at a third, which would result in a big reduction in casting-shop costs.

The possibility of using the casting process for pieces other than hollow ware is also worthy of consideration. A process for making plates, built up from this idea, is described in Part IV, p. 218, of this Report.

(4) Mold Life

Mold cost is an important item in any ceramic plant; any process, therefore, which lengthens the life of molds is a valuable aid in reducing production costs. Both sodium gallate and the No. 2 clay deflocculant were easy on the plaster molds, the latter being somewhat better in this respect. After 150 casts in molds made from a 1.25 to 1 mixture of plaster and water, the mold was still in excellent condition. The opinion of the journeyman caster was that the average mold life could be doubled over that in the average semivitreous dinnerware plant.

(5) Use of Humic Acid

With each deflocculant, small amounts of humic acid* were added in the approximate proportions of 10 to 20 grams per 100 lb. of pug-mill rolls. This addition of lignite improved the casting properties and apparently caused an all-kaolin body to work similarly to that with a high percentage of ball clay, which suggests that the ball clay is helpful in making casting slip because of its possible humic acid content. Undoubtedly, there are other organic acids in ball clays which vary in kind and amount and which, by the same token, cause variations in the casting properties of slips made from bodies containing ball clays. If this theory is correct, it is obvious that the addition of the humic acid under control is a great advantage.

* Kassler Braun from R. & H. Chemical Co.

IV, NOTES ON LABORATORY EXPERIMENTS IN THE PRODUCTION OF FLATWARE

By R. E. Gould and G. W. Fichter

Abstract

Further experiments are reported on the bisque firing of plates with mechanical braces to hold them straight. By bracing the rim and bottom of the plate, the force exerted is more than the internal strains in the plate tending toward deformation, and the plates so fired come to the desired degree of straightness, provided the dimensions are correct. The permissible variations in the dimensions are not more than ±0.001 inch. This dimension is attained by trimming the feet and rings in the leather-hard state to the prescribed measurements. A new method of making flatware cheaply by casting the plate and overcasting the foot is described. This method is successful if the mechanical bracing in the firing process is used.

I. Introduction

Part VI (p. 202) of Progress Report No. 1[1] dealt with the problem of holding the rims of plates rigid during the firing process to overcome their tendency to be crooked owing to internal strains. In this study, plates were held rigid during the bisque-firing process by rings overcast around their edges and by disks placed between the plates at their centers, because the inclination of a plate to deform is most noticeable at the rim and in the center. The deformation would be naturally exaggerated as the body approaches complete vitrification because, at this firing point, there is an actual softening, even when the best materials are used. This softening, furthermore, tends to permit the relief of the internal strains which are caused by the manufacturing process.

Note: A part of the art or skill of a potter is devoted to avoidance of strains which cause flatware to warp in the formed pieces. The design of the flatware is important, but with all the potter's art and ware design, crooked flatware is not wholly obviated in the customary potting methods. Internal stresses in the body are not necessarily limited to those traceable to workmanship or design. Variations in the materials and in their preparation, different amounts of water, unequal drying, removal from the mold before complete drying, and the use of an improperly designed jiggering tool are factors which cause crooked ware.

A preliminary study disclosed that in plates bunged up with rings and disks the crooked plates could be traced directly to the degree of mechanical imperfection of the rings; *e.g.*, rings too thick in proportion to the thickness of the foot plus the bottom of the plate would cause an accumulative error so that plates through to the top of the bung would be progressively deeper. In Fig. 1, A is the height of the rim from a plane surface passed through the foot as represented by the bottom plate of the bung; a is the excess thickness of the ring plus the rim of the plate over the thickness of the foot plus the bottom; and x is the number of plates in the bung; the dimension of the top plate between a plane passed through the bottom of the foot and the rim therefore would equal $A + xa$, or the accumulative error due to improper dimensions.

If rings were not equal in thickness, all plates in the bung would be affected as represented by Fig. 2; thus crooked plates may be caused by rings of unequal thickness or by a ring whose thickness varies within itself, in which case all plates above are affected by going crooked or by becoming progressively deeper or flatter.

The bung of plates (Fig. 2, cross section) is a mechanical structure so built up that bracing by the rings will take place at all times on the rims through the feet and by the disks at the center of the bottoms where there is a tendency to sag. The dimensions in the manufacture of the rings, disks, and plates therefore must be within close limits; an error of 0.002 to 0.003 inch is possibly the greatest that can be tolerated.

Approximately 50% of the plates made according to the experiments recorded[2] were sufficiently good to be classified as straight, but in most cases the straightness or crookedness was more by accident than by design. Unless each piece were made within the limits of ±0.001 in., the accumulative error in a bung of 24 pieces would exceed 0.024 in. at the top of the bung, which would be too crooked.

II. Present Investigation

(1) Inaccuracy in Jiggering

The experiments were conducted under what were believed to be closely controlled jiggering conditions, *i.e.*, the machine was made to run as true as possible and the tools were carefully set by a gauge. In measuring the fired pieces, however, a variation of ±0.010 to 0.015 in. was the best that could be obtained. This variation was first thought to be caused by the amount of spring in the jigger pulldown, and a new type of jigger was procured which had a very strong pulldown with a web and flange. This pulldown was swung on a horizontal 2-in. shaft, equipped with two snugly fitted, extra strong roller bearings instead of the usual type. Plates made on this machine showed a slight improvement but still varied by ±0.008 in.

Further sources of error were checked, and it was found that carefully made molds from the same case varied several thousandths of an inch over different parts of the surface. The molds did not fit perfectly into the jigger head. Although obviously impractical, an attempt to correct these features was made by (1) grinding the jigger head to a variation of ±0.00025 in., (2) machining each mold to ±0.0005 in., and (3) using the improved pulldown but having a stop at the end to prevent any spring in the member itself.

Many plates made with this more exact setup of jigger and mold still showed a variation of ±0.006 in. Further study revealed the fact that the plastic clay was springing up underneath the tool and that there was a probable "difficult-to-control" difference in shrinkage

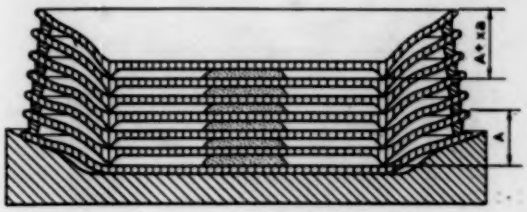

FIG. 1.

due to the amount of water applied during the jiggering process, fast drying, design of plate, etc. This was especially true of the foot, which in some cases was largely composed of slurry.

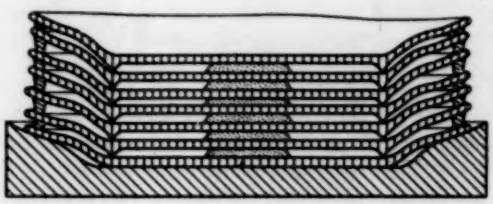

FIG. 2.

(2) Trimming Plates and Rings to Exact Dimensions

Because it seemed to be impossible to jigger the whole pieces within the limits of tolerance, it was decided to jigger the ware as usual and to trim the pieces to the necessary dimensions while in a leather-hard state. Inasmuch as the bracing takes effect through the foot and at the rim, these two places only were kept within the exact dimensions. The fired dimensions of pieces trimmed in the leather-hard state may be closely controlled. This method is used in the ceramic industry for forming various types of ware. Trimming the foot to the desired dimensions offered no insurmountable difficulties; the rim of the plate, however, presented problems not so easily overcome.

(3) Redesigned Ring

The thickness of the rim is as important as the thickness of the ring which is to be overcast; the important dimensions of the ring therefore were brought outside the plate rim, whereby the rings themselves would be the support (see Fig. 3). The rings, cast in a machine-cut mold, came within the limits of tolerance (see Fig. 4). The method appeared to be practicable, and the results were reproducible. Approximately 50 rings could be cast in such a mold before re-machining of the surface was necessary.

(4) Base Plate

The base provided for the bung of plates was prepared from a refractory sagger body, preformed in a mold and ground true in the lathe after firing. This piece must resist warping, and it should be placed upon a flat surface for firing.

(5) Cutting the Foot

In the machine for cutting the foot (Fig. 5), the piece is drawn down to a true plate, *A*, by a vacuum, and the foot is trimmed by the cutter, *B*, which moves in a horizontal position set to the desired dimension from the plate, *A*. Trimming the pieces in the leather-hard state indicated that the dimensions after firing were within the limits of tolerance of ±0.001 in. One necessary change was to move in the foot (Fig. 6).

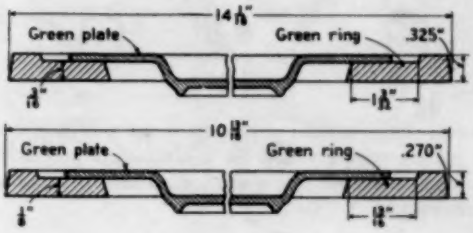

FIG. 3.

(6) Results

The results were encouraging, and, with the correct dimensions, it was possible to reproduce ware which was not only straight but which duplicated straight ware from other bungs made under the same specifications.

NOTE: The method of testing bungs of plates for straightness was to bung up the finished ware and to inspect it. Plates were classified as straight when they could be shuffled within the bung and mixed with other bungs without appearing to be crooked.

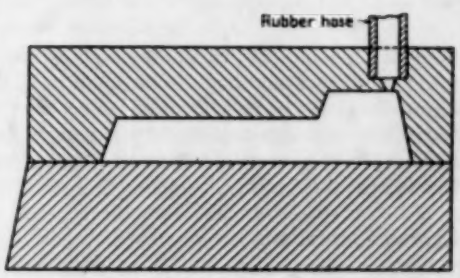

FIG. 4.

III. Making Plates with Flat Rims

Up to this time, the jiggered plates were of the usual conventional design and weight. A more rigorous test of the production method would be to reduce the weight of the pieces and to make them with flat rims so that

there could be no conceivable bracing within the ware itself. The two sizes of plates used are shown in Fig. 3.

(1) Casting Plates

Easily controllable casting slips were made by controlling the viscosity, specific gravity, and "castability," and the pieces cast for the same lengths of time had equal thicknesses and weights (see Part III, p. 214). The draining of this casting slip was very good. These

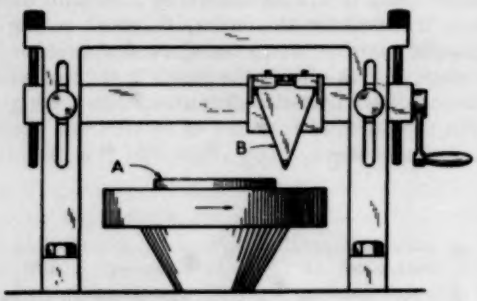

FIG. 5.

features of the casting slip suggested the idea of casting the plates, which would be a simplified process inasmuch as no skilled operations, machine, or tools would be necessary.

(2) Casting Apparatus

An apparatus was designed for overcasting the plate (Fig. 7). It was necessary to have a ring or dam to hold the slip on the mold which, when removed, would have no tendency to pull off the setup body. The ring would have to release itself from the entire

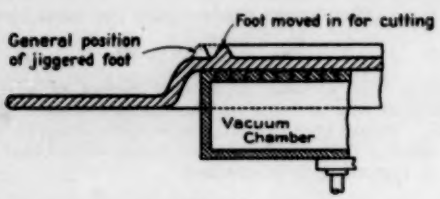

FIG. 6.

periphery of the mold (*i.e.*, in all directions at the same time) and draining would have to be equal in all directions from the center, if a "curtained" effect were to be avoided. This was accomplished by placing a flexible rubber ring inside of a metal band and inflating it until it contacted the molds (Fig. 7).

(3) Casting Operations

The casting operations were (1) to place the mold inside the deflated ring; (2) to apply air pressure (approximately 5 lb. per sq. in.) to inflate the rubber ring to the point of contact with the mold (Fig. 7); (3) to pour slip into the ring to cover the mold (Fig. 8); (4) to release the air pressure which deflated the rubber tube and permitted the excess slip to flow off without disturbing the setup body (Fig. 7); (5) to remove the excess slip by whirling the mold in the jigger head (Fig. 7); and (6) to trim off the excess clay from the edge of the plate to the outside of the mold; this trimming was done with a knife by starting the knife point under the clay at the outside rim of the mold, bringing it in toward the center so that the knife blade passed through the edge of the plate and just over the back surface.

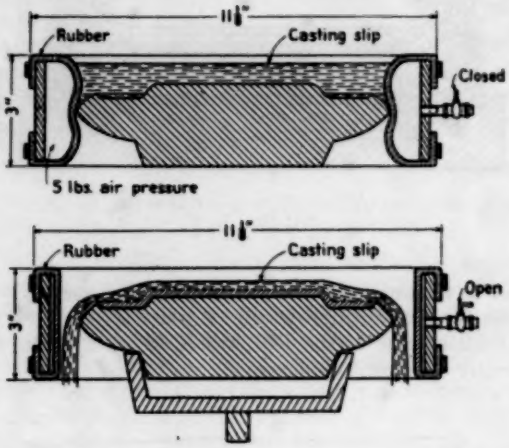

FIG. 7.

IV. Casting the Foot

Casting of the bat was easy and successful except that the plate so formed was without a foot. (Feet on plates are customary, although for practical use they are unnecessary.) Overcasting the foot was done immediately after whirling off the excess slip (Fig. 9).

After the plates had dried to the leather-hard state, they were removed and the foot was turned on the machine (shown in Fig. 5).

Many trials with this method indicate that (1) good ware can be obtained; (2) the necessary motions can be easily mechanized; and (3) the machinery required consists essentially of a conveyer belt. Operators would be needed to place the molds in the rings for whirling off the excess slip and to place the foot molds upon the semifinished pieces, but these operations could also be accomplished mechanically.

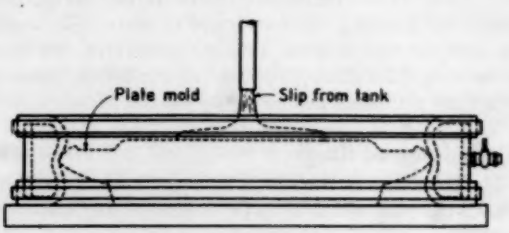

FIG. 8.

Another advantage of this type of manufacture is the elimination of different machines for different pieces. With the same type of apparatus, it is possible to overcast a saucer as easily as a service plate or a baker or platter. The substitution of several simple

mechanical motions for one very complicated motion is entirely feasible. The success of the operation depends primarily upon the controlled casting slip being delivered to the machine because variations in setting-up time or a too lengthy period obviously would make a variable product.

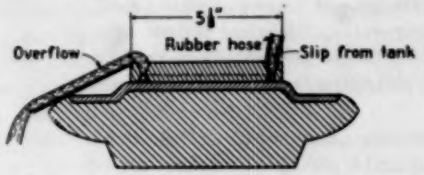

FIG. 9.

Several hundred dozens of pieces were made by this method to show that the ware is easily reproducible and that the variations in the weight of the piece are not more than those encountered in usual practice.

(1) Re-Use of Rings

In the beginning, only green rings were used, but one ring per plate made this too expensive; the rings should be re-used. The design was changed (Fig. 10) by lengthening the inner lip of the ring and by increasing its over-all diameter so that the green plate would just fit inside a fired ring (Figs. 10 and 11).

A body, more refractory than that from which the plates were made, is necessary because the rings overfire and blister upon repeated trips through the kiln (see Fig. 12). The elimination of the dolomite from the bodies overcame this difficulty, and with careful handling, the rings may be re-used for one hundred or more firings. The use of a more refractory body is also preferable because such a ring may be dry-pressed and, after firing, may be ground to exact size.

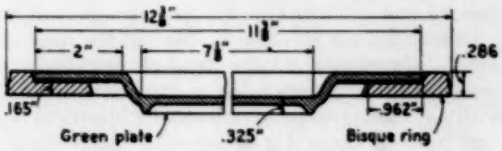

FIG. 10.

NOTE: Crooked bungs were found occasionally, especially where one ring in the bottom had cracked and spread out, causing a drop in all of the rings and plates above it; this occurred particularly when green rings were used. The pieces were straightened by removing the bottom ring and placing the crooked rings and plates back into the kiln. This proves that softening the body at maximum temperatures is sufficient either to deform the pieces or to straighten them. If the dimensions of the foot and ring are correct, the crooked plates may thus be straightened.

(2) Advantages of Ring Supports

The experiments thus far prove the feasibility of using this bracing method in firing flatware. It should make possible a simplification of the entire potting process. The rings permit 24 pieces of delicate ware to the bung; under ordinary circumstances they can not be placed more than 6 to 8 pieces high.

Another advantage of the use of rings is the decrease in the firing time of the bungs. The use of sand, flint, calcined clay, or alumina as a brace between the rims of the plates makes it necessary to have a slow temperature rise in the kiln to permit the heat to permeate the bung. Sanded bungs tend to go crooked if a temperature rise of 5° to 10°C per hour is exceeded, especially after a 1000°C kiln temperature has been reached. Plates, braced with rings, have been successfully fired with a temperature rise of 75° to 125°C per hour. This temperature rate apparently is limited only by the ability of the body to withstand heating-up and cooling-down strains.

NOTE: With the electric tunnel kiln described in Part V, a cycle of 24 hours was the maximum which could be used to obtain well-fired bungs of service plates, and at this temperature, the pieces in the middle of the bung were apt to be dunted. Because dunting was the only fault observed, it was believed that this could be overcome easily by having a longer cooling section on the kiln. The maximum weight per bung fired successfully was 75 lb.

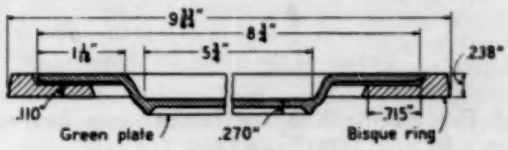

FIG. 11.

V. Support of the Plate Bottom

It was thought that a disk would be the correct brace for the bottom, but the experiments indicated that, unless the bottom of the piece were turned to exact dimensions, there would be an accumulative error, owing to the thickness of the bottom of the plates and of the disks. The method was changed to the use of a "dottle," which is a mixture of calcined and raw clay (approximately 50 to 50) and which has about the same shrinkage as the body itself; this "dottle" is placed on the center of each plate.

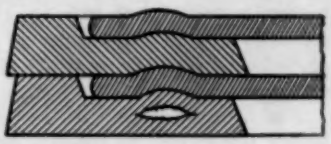

FIG. 12.

VI. Conclusions

This experiment to produce straight plates is believed to point the way to one successful method which depends more on mechanical ingenuity than actual potting skill for its practical development. By casting the plate bat, overcasting the foot, and using ring braces that carry the bung-load of plates, the production of plates with a minimum of warping is possible.

The number of successful pieces of flatware made in this manner is too limited to have solved definitely all production problems. This work will be continued.

Acknowledgment

The writers wish to acknowledge the suggestions and services of D. A. Deaderick and other members of the laboratory staff.

V, ELECTRIC KILNS AND FURNACES

By R. E. Gould, M. G. Toole, and M. S. Nelson

Abstract

An experimental electric tunnel kiln firing to cones 13 to 14 is described. This kiln is different from previous electric-kiln experiments in the type of heating elements used, their position in the kiln, and the method of heat recuperation. Heating is done by a new graphite resistor operated at low wattage dispersion placed horizontally in the kiln to heat the charge from underneath and on top. The difficulties in putting the kiln into operation are described.

The experiment was undertaken to answer three primary questions, *viz.*, (1) do resistors exist that will heat properly to these temperatures and is their life "commercial" in cost and ease of manipulation; (2) can heating be done evenly over given cross sections; and (3) what are the relative costs of using electricity as a fuel compared with other types, such as gas, oil, or coal?

The operation of the electric kiln was successful after it was adjusted mechanically; no grave difficulties were encountered in the heating elements, and the heating over the cross section used was even.

From the data obtained, it appears that under certain conditions the use of electricity as a fuel can compete with gas or oil. The power input into the kiln for any given temperature is a constant, and the power consumed per unit weight varies inversely with the weight of the charge per cubic foot and the speed of schedule.

(A) The Electric Kiln for Temperatures between 1100° and 1400°C

I. Introduction

The use of electricity for heating is advancing rapidly, although its progress in ceramics has been much slower than in other fields. This is particularly true if the temperatures involved are above the safe limits (1100° C) for the metallic resistors. Several investigators have endeavored to utilize electricity as a heating agent for higher temperatures (up to 1400°C), especially in localities where electric power is cheap and other types of fuel are expensive or where exact heating control is essential.

The firing operation in the ceramic field, especially before the advent of the continuous combustible fuel-fired kiln, was a source of so much trouble and annoyance that electricity has long been regarded as a possible ideal fuel,* and the many attempts to build kilns have met with varying degrees of success. Most ceramic firing temperatures lie between cones 6 and 14, which are above the safe limits for the metallic-type heating element. This may be one reason why electric kilns are so infrequently used in this industry.

II. History

In 1905, Richard Lichtenstein[20] first suggested the use of electricity to heat tunnel kilns firing semivitreous ware. A power plant was built for this purpose. Harper[21] started experimental work a few years later on a high-temperature electric kiln for bisque-firing vitrified hotel china; this kiln was described in 1926. Apparently so many difficulties were encountered in the heating elements that the experiment was abandoned.

Odelberg built a kiln in 1925, using Morganite resistors for glost firing cups. Preliminary results were so successful that two larger kilns were built, and experiments were conducted in bisque firing to temperatures of 1280°C. Odelberg[22] reported in 1927 that (1) savings in sagger costs were greater than the cost of the resistors, (2) rejects in the electric kiln were under 1%, and (3) savings in bad ware "more than pay for the running costs of an electric kiln." In 1937, however, Odelberg[23] said, "With regard to biscuit and glost tunnels, I think the gas producer . . . is still the most economical. I have, as you know, tried electrically heated tunnels, but have given it up, partly because of the difficulty of finding suitable resistors for electrical heating and partly because it is so difficult to place the glost ware without saggers. . . . We have run an electrically heated double glost kiln for ten years and just recently have given it up."

In 1936, Bullin[24] said, "while these elements (non-metallic) are quite suitable for small experimental furnaces, their life is still too short for practical tunnel-kiln work. Two kilns in this country (England) have been abandoned owing to this difficulty." Reports on the successful operation of three Globar-heated kilns firing to cones 9 to 10 in Switzerland are given by

* In this paper, electricity used for heating is referred to as a fuel.

[20] Felix Singer, Der Tunnelofen. Chemisches Laboratorium für Tonindustries, Berlin, 1933; *Ceram. Abs.*, **13** [3] 69 (1934).

[21] F. A. J. FitzGerald, "Harper Electric Kiln," *Jour. Amer. Ceram. Soc.*, **9** [11] 766–72 (1926).

[22] A. S. W. Odelberg, "Electric Tunnel Kiln," *ibid.*, **10** [3] 210–19 (1927).

[23] A. S. W. Odelberg, "Pottery Manufacture," *Trans. Ceram. Soc.* [England], **36** [2] 56–62 (1937); *Ceram. Abs.*, **16** [9] 280 (1937).

[24] L. Bullin, "Recent Developments in Ceramic Firing," *Trans. Ceram. Soc.* [England], **35** [2] 53–96 (1936); *Ceram. Abs.*, **16** [1] 36 (1937).

Bullin,[24] Gatzke,[25] and Masukowitz.[26] One of these kilns, put into service in April, 1933, had been giving uninterrupted service up to June, 1936.

A kiln for heating hard-fire porcelain to cone 14 was put into operation at the Langenthal Porcelain Factory in Switzerland in August, 1937, and the results[27] were given in 1937. This kiln was heated to 1410°C by Globar resistors, and the glost ware was fired under reducing conditions.

A test kiln using silicon-carbide heating elements has been erected and successfully operated at the National Bureau of Standards.

The use of electricity for heating at lower temperatures, *e.g.*, in decorating and enameling kilns, has been quite successful. Results have been reported by Eves,[28] the Brown Boveri Company,[29] Smith,[30] Stoler,[31] Hertzell,[32] and others. In kilns heated to these temperatures, the manufacture of the heat itself presented no great difficulties because the temperatures were within the safe limits for the Nichrome-type resistance heating elements.

Despite the fact that the use of electricity for heating has been reported as successful and economical in a few of the installations referred to, it is still regarded by ceramists with skepticism. The failures which have been reported appear to overshadow the good results, and it is generally believed that high-temperature electric kilns (for cones 9 to 14) are impracticable for the following reasons:

(1) No heating elements exist which have a suitable life at these temperatures.

(2) Electric heating is done largely by radiation, and the heat distribution over any given cross section will be poor because the heating probably will be according to the laws of radiation which vary inversely as the second power of the distance from the source.

(3) Electricity will never be able to compete with other types of cheaper fuels because of the comparatively high cost of the heating unit as derived from electricity (3415 B.t.u. per kw.-hr.) in comparison with that derived from coal, oil, or gas. Even with cheap power, *e.g.*, at 5 mills per kw.-hr., one million B.t.u. cost $1.464, compared with the cost of the same number of heat units from coal at $5.00 per ton (14,000 B.t.u. per lb.), which is $0.1786; from natural gas at 40 cents per 1000 ft. (1000 B.t.u. per cu. ft.), which is $0.4000; and from oil at 5 cents per gal. (144,000 B.t.u. per gal.) which is $0.3472.

(4) For proper firing, ceramic ware requires bathing in hot gases, and radiation alone (such as would be encountered in an electric kiln) would result in a "toasting" effect on the ware. The outside only would be fired to the desired degree of vitrification.

These contentions are based partly on actual and rather bitter experience and partly on calculated results, based on theoretical considerations. It is just as possible, however, to present an attractive theoretical case for the high-temperature electric kiln which would justify its use. Some of the advantages might be as follows:

(1) The electric kiln is clean and free from moisture. Because it does not rely on combustion for heating, it would not have the objectionable flue gases which contain, in greater or less amounts, SO_2, SO_3, H_2O, CO_2, and CO, any one or combination of which can (and usually does) have undesirable effects.

(2) Electric heating should be easily controllable. Because the heating effect is caused by the voltage and current supplied to the resistor, any temperature within practical limits could be attained and automatically held with the existing commercial types of equipment.

(3) Inasmuch as the atmosphere in the kiln can be imagined as clean and controllable, no saggers would be necessary and their relatively high cost could be saved.

(4) It should be possible to supply electric heat when and where it is desired. In most furnaces fired by combustible fuel, preheating is done by outgoing, cooling-down, shrinking flue gases if the heat units are to be partially saved. This condition does not always give the most desirable preheating schedule, and because the flue gases shrink in volume upon cooling, there is difficulty in maintaining an even temperature over any given cross section. In an electric kiln, it appears possible to show a more theoretical heating curve, thus saving time and producing a greater volume of ware for a given kiln cross section.

(5) The electric kiln produces no atmosphere of its own; it should be possible therefore to fire ware in highly oxidizing or other types of atmosphere, if this were necessary or desirable.

(6) Because the electric kiln would have no stack, the counterflow plan could be used so that heat from the cooling-down ware could be reutilized in preheating; this is a desirable plan which is not easily conceivable in gas- or oil-fired furnaces.

(7) It should be possible, with a few known facts, to design a kiln to utilize the electrical heat unit to its fullest extent, thereby compensating largely for its greater cost.

(8) Assuming that heating could be done evenly, it would be possible to fire a more delicate and sensitive type of ware rapidly and to reduce to an absolute minimum the rejects caused by the firing.

A review of the literature as well as an examination of failures and successes in high-temperature electric heating indicates one possible explanation both for the

[24] Paul Gatzke, "Electrical Firing Methods in Ceramic Kilns," *Ber. deut. keram. Ges.*, **17** [6] 297–304 (1936); *Ceram. Abs.*, **15** [9] 283 (1936).

[25] (*a*) H. Masukowitz (abstract and translation), *Keram. Rundschau*, **43** (1935).

(*b*) H. Masukowitz, "Extent Today of Use of Electric Heat in the Ceramic Industry," *Elektrowärme*, **6** [1] 30–37; [4] 123–28 (1936); *Ceram. Abs.*, **17** [3] 112 (1938).

[27] *Bull. Assoc. Suisse des Electriciens*, No. 19 (1937).

[28] J. R. Eves, "Continuous and Periodic Electric Decorating Kilns," *Jour. Amer. Ceram. Soc.*, **11** [10] 753–58 (1928).

[29] *Brown Boveri Rev.*, **24** [1–2] 48–50 (1937).

[30] A. J. G. Smith, "Electric Decorating Kilns," *Elec. Rev.*, **122** (July 30, 1937).

[31] S. M. Stoler, "Continuous Equipment for Porcelain Enameling," *Amer. Enameler*, **2** [12] 14–15 (1930); *Ceram. Abs.*, **9** [7] 510 (1930).

[32] E. A. Hertzell, "Fuels for Enameling Furnace," *Amer. Enameler*, **2** [10] 8–9 (1929); *Ceram. Abs.*, **9** [3] 165 (1930).

failures and the achievements up to the present time. This is the fact that ceramists in general have a limited knowledge of the use of electricity as a fuel and electrical engineers are not familiar with ceramic processes and the difficulties which are likely to be encountered.

III. Present Investigation

With no preconceived ideas regarding the success or failure of the electric kiln, the Tennessee Valley Authority began an investigation of high-temperature electric heating to determine the fundamentals involved,

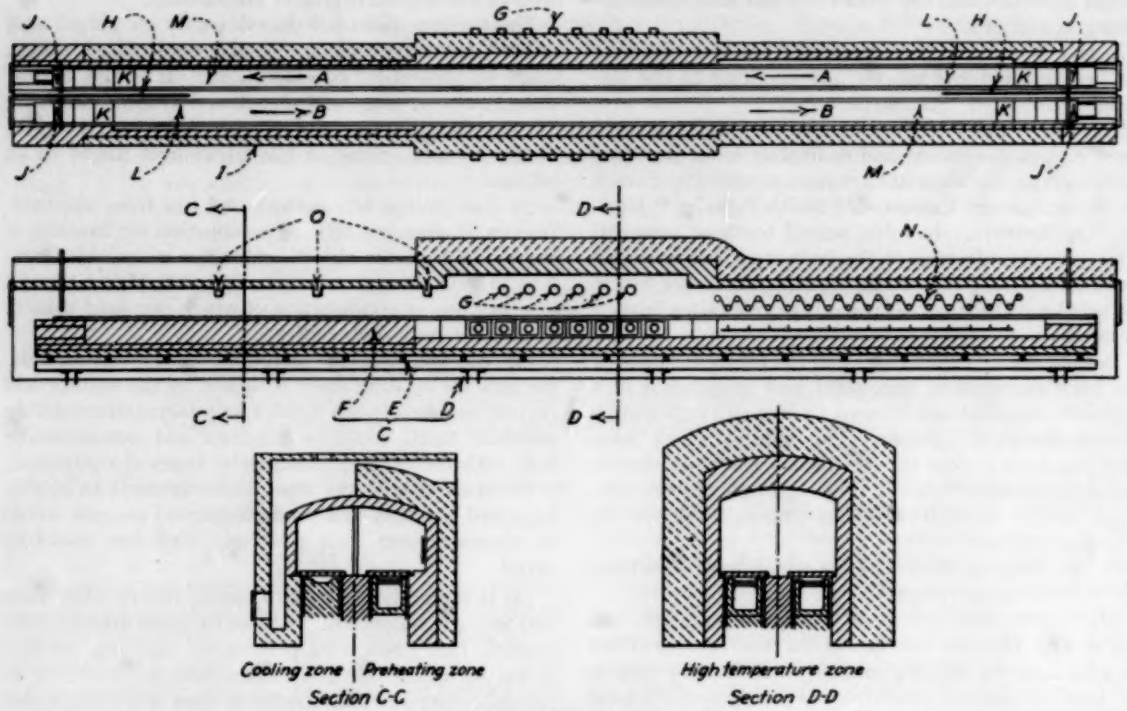

FIG. 1.—Details of kiln construction.

Letter	Description	Remarks
A and *B*	Moving streams of ware	
C	Vertical section through walking beam	*D*, *E*, and *F*; three main parts
D	Vertical lifting beam	
E	Rollers	Move horizontal traveling beam
F	Horizontal traveling beam	Moves in longitudinal direction
G	Resistors	8 in bottom; 6 in top
H	Septum dividing two tunnels	
I	Steel shell	
J	Doors	
K	Slabs	
L	Preheating zones	
M	Cooling zones	
N	Metallic resistors in preheating zones	
O	Baffles	

The known successes are electric kilns built by firms primarily educated and interested in the ceramic processes. In such cases, electrical engineering was used to the extent of supplying the necessary knowledge to make the installation practicable. The success of electric kilns in the future must be based on the proper combination of electrical engineering and ceramic knowledge.

hoping that some of the answers could be found to the major objections now being raised not only by ceramists but also by other possible users of electric heating. It was hoped that this investigation might help to bridge the existing gap between the electrical and ceramic viewpoints.

Because heating operations up to 1100°C are used commercially with success, the laboratory staff decided

to experiment with temperatures between 1100° and 1400°C. The majority of the experiments were to be conducted at cone 14 because, if operations at this temperature proved to be successful, the chances of the kiln to work at the usual temperature limits of cones 9 to 12 would be doubly assured.

Certain fundamental principles were investigated in a definite order, *viz.*, (1) different types of resistors to furnish the heat; (2) different modes of application of the heat, *i.e.*, the positions in which the resistors should

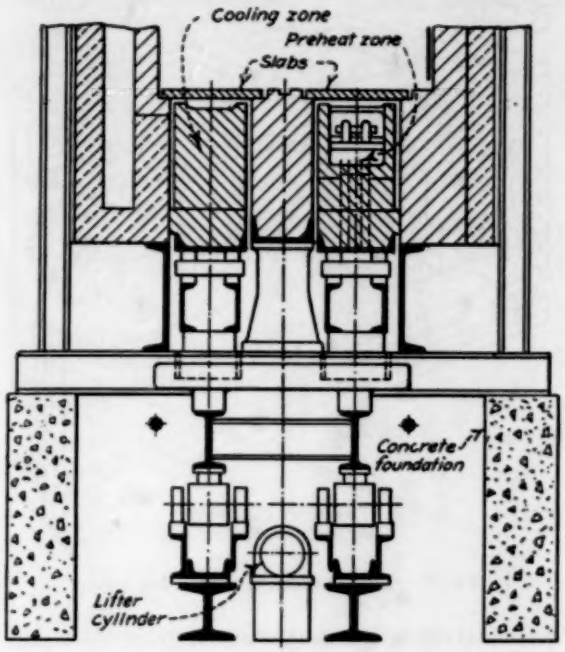

FIG. 2.—Section through walking beam.

be placed, etc.; (3) heat distribution to determine the maximum practical size of inside kiln dimensions; (4) different types of atmosphere; (5) various schedules to determine the effect of speed on the ware and power consumption per unit; and (6) the approximate design of a continuous kiln to forecast the probable cost of using electric power for this type of heating.

(B) Design, Construction, and Operation of an Experimental Continuous Electric Kiln

I. Introduction

The investigation of preliminary schedules, the use of reducing atmospheres, and the test results run on the electrical firing of porcelain and chinaware to cone 14 have been reported.[33] Different methods of manufacturing electric heat, *viz.*, by (*a*) the recrystallized silicon-carbide bar, (*b*) the graphite resistor, and (*c*) the high-frequency furnace have also been recorded.[34]

These experiments indicated that the best theoretical type of continuous furnace would have the following main features:

(1) Top and bottom heating, *i.e.*, a furnace in which the heat is supplied underneath and on top of the charge.

(2) The use of the counterflow principle, *i.e.*, the tunnel type in which two streams of ware go in opposite directions; with this method, it should be possible to recuperate a large amount of sensible heat from the outgoing ware.

(3) Atmospheric and pressure control, so that if another atmosphere than air were needed, it could be used and the firing could be done under positive or negative pressure or both.

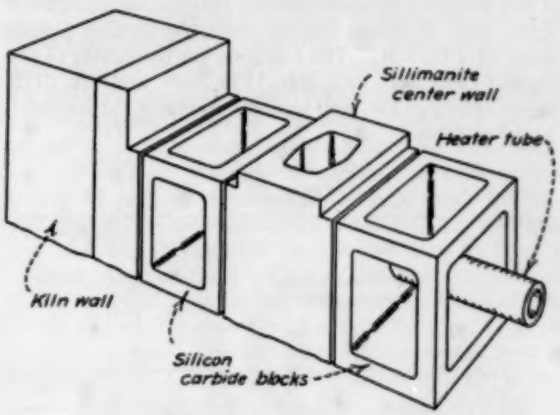

FIG. 3.—Lifter blocks in furnace zone.

(4) Constant electrical load, which is believed to be extremely important from the power-supplier standpoint; obviously, a good load factor would be more desirable than one which varied, as in an on-and-off control, even though the total power consumed would be the same.

(5) Moderate installation cost, which would not exceed the cost of a similar production unit heated with gas or oil for a given amount of charge of a given quality; it is important, in this connection, that the heat- and power-control apparatus should be reduced to a minimum.

II. Description of Kiln

(1) General Description

A continuous, electrically heated kiln was constructed primarily to obtain data on the following points:

(1) To test various types of resistors which, from previous experience, seemed to have possible commercial application at these temperatures; these resistors were

[33] R. E. Gould and M. G. Toole, "Preliminary Experiments for Development of a Continuous Electric Ceramic Kiln for High-Temperature Firing," *Trans. Electrochem. Soc.*, **70**, 111–41 (1936); *Ceram. Abs.*, **16** [7] 217 (1937); see also footnote 2, p. 205 of this Report.

[34] M. G. Toole and R. E. Gould, "Progress Report on Tests of Various Electric Heating Elements for Furnace Temperatures between 1100° and 1500°C, I," *Trans. Electrochem. Soc.*, **70**, 89–109 (1936); *Ceram. Abs.*, **16** [7] 217 (1937).

to be installed in a horizontal position and placed underneath and above the charge.

(2) To determine whether the heat distribution (even over the comparatively small area) would be uniform, and to determine further the approximate size limits which would be commercially feasible for the electric kiln.

(3) To obtain some idea of the basic design principles to be used in constructing electric kilns to make this type of firing practicable.

(4) To obtain data on the cost of electric firing as compared with other types of fuel.

Because the kiln was to be used only for experimental purposes, the smallest size was chosen which would give practical results. The kiln was 55 ft. in over-all length, and the inside dimensions of the tunnel were 2 ft. 11 in. wide and 1 ft. high to the spring of the arch; it was designed to accommodate two moving streams of ware, each of which had an available vertical setting space of 1 by 1 ft. The hot zone (in the center of the furnace) was 15 ft. long, 2 ft. 11 in. wide, and 1 ft. 10 in. to the spring of the arch to make room for the top horizontal resistors.

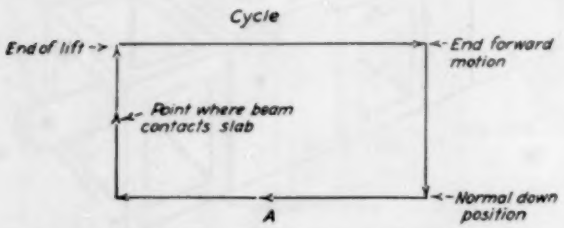

FIG. 4.—Path of movement in walking beam; (*A*) beginning and ending of cycle (arrows show direction of movement).

The ware was moved through the kiln by two walking beams which move in opposite directions. With simple changes, these two beams may be made to move in the same direction. The charge was placed upon slabs, 14 by 12 in., so that each slab may carry 1 cu. ft. of ware. The speed of flow through the kiln was regulated by the length of the stroke of the beams and the number of strokes per hour.

(2) Details of Kiln Construction

Figure 1 (p. 18) shows a typical section of the kiln.

(3) Walking Beam

Figure 2 shows a vertical section through the walking beam in the hot zone and parts of the preheating and cooling zones. The silicon-carbide lifter blocks are shown in Fig. 3; the path of movement of the walking beam (Fig. 4) permits the resistor to be placed through these moving blocks, giving a horizontal clearance of $4^1/_2$ in. and a vertical clearance of $3^1/_2$ in. The type of lifter block in the preheating zone is shown by Fig. 5 and in the cooling zone by Fig. 6.

Figure 7 is a schematic layout of the walking-beam mechanism. The movement of this mechanism is as follows: the pump, *A*, is started by the electric timing device, *B*, which causes the horizontal cylinders, *G* and *H*, to move from their midway position to the back end of stroke; the entire lifting-beam structure, *C*, rises vertically by cylinder, *D*. This raises the main horizontal I beam, *E* (which extends the full length of the kiln) contacting the slabs, *F*, and lifting them from the bench along the kiln walls. When cylinder, *D*, has reached the end of its stroke, pressure from the pump, *A*, is directed by pressure valves to the opposite end of the

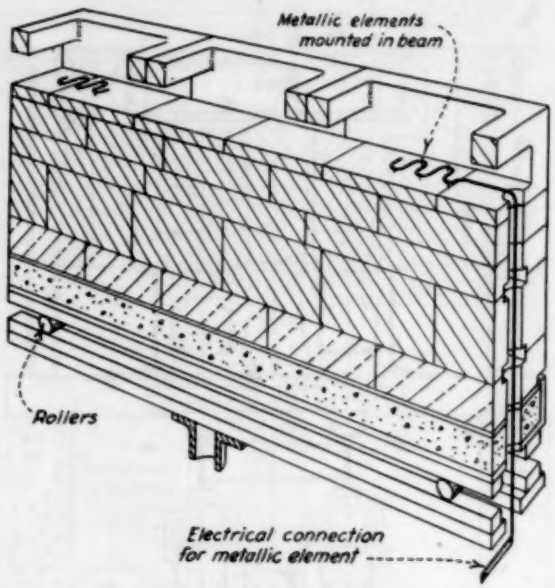

FIG. 5.—Lifter blocks in preheating zone.

horizontal acting cylinders, *G* and *H*, from which pressure was last applied, thus moving the parts of the beams, *J* and *K*, above the rollers, *L*, in the desired directions. When the forward limits of stroke of these cylinders are reached, the pump, *A*, is stopped, and the lifting beam structure, *C*, returns to the lower position by gravity, permitting the slabs to come to rest on the bench in the kiln in the advanced position. The return of the lifting beam, *C*, to normal restarts the pump, *A*, causing the horizontal cylinders, *G* and *H*, to return to a midway position, at which time the cycle is complete.

(4) Resistors and Electrical Connections

Although the entire field of high-temperature electric heating was not thoroughly investigated, it soon became evident that the graphite resistor and the recrystallized silicon-carbide bar were the best possibilities for a successful commercial heating element which would not require an enormous amount of developmental work of questionable outcome.

Most important of the considerations in the study of resistors was to develop a satisfactory heating element to fit the particular kiln conditions necessary for successful electric heating.

These conditions were (1) top and bottom heating; this would require a resistor which could be used successfully in a horizontal position; (2) the resistor should not

be excessive in cost, and the average mechanic should be able to manufacture it from ordinary furnace stock; (3) no water cooling of the terminals should be necessary; this is a source of trouble and requires an expensive installation; (4) the wattage dispersion should be reasonably low (not exceeding 30 watts per sq. in.) to avoid the "toasting" effect; (5) to obviate the necessity for expensive voltage regulation equipment, the resistor should not change in resistance with age; (6) it should be possible to change the resistor easily and without shutting down the operation or seriously affecting the heating.

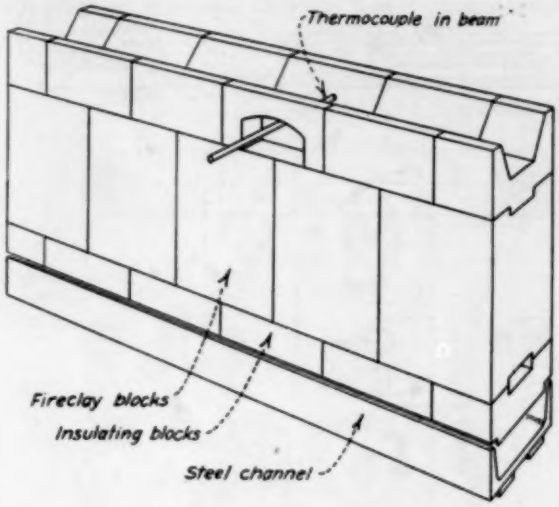

FIG. 6.—Lifter blocks in cooling zone.

A graphite resistor seemed to have possibilities for the following reasons, *viz.*, graphite is (*a*) a good conductor of electricity, (*b*) easily machinable by the average mechanic, (*c*) stable up to its sublimation point of over 3600°C, (*d*) moderate in cost, and (*e*) not subject to change in electrical conductivity with age, providing there is no reduction in cross section by oxidation.

Many trials were made with the recrystallized silicon-carbide bar, and its behavior was satisfactory from the standpoint of heating and life. This type of element changes in resistance with age, which is a drawback, although in furnaces of a constant temperature, where the bar is energized most of the time, this change in resistance with age is gradual. Because the life of the bar seems to be determined largely by the gain in resistance (failure occurs at a point of increase between 200 and 700%), it is important (1) to handle the bar so that the increase in resistance will be at a minimum and in a constant amount and (2) to provide proper electrical equipment for raising the voltage with greater resistance to get the required heat output. This equipment may be purchased, and its use is strongly recommended; otherwise the life of the bars will be too short to be of commercial value. Experiments carried on in the laboratory indicate that at cone 14 an average life of at least 2000 to 3000 hours may be expected with intelligent handling[24]; this average may be increased with a proportional gain in experience.

Figure 8 shows a resistor assembly used in heating this kiln. The history and development of this resistor have been recorded up to July, 1936,[24] and the data up to date will be published.*

This resistor consists essentially of a graphitized carbon rod, *A*, turned down to a given diameter to provide the required heating capacity. (The heating capacity of the elements on the ends of the hot zone was greater than in the center to compensate for the chilling effect of the cooling zones.) Rod *A* is screwed into graphite terminal blocks, *B*, which are tapped and threaded on the outside ends for copper terminal connections, *F*. The entire assembly is placed in a clay-bonded silicon-carbide tube, *C*. The ends of the tubes are closed by semiflexible copper or Nichrome diaphragms, *D*, held tightly by asbestos packing rings, *K*, which in turn are held by packing glands, *E*. Electrical connections to the graphite assembly are made through the copper bar, *F*, which screws into the terminal block, *B*. Bar *F* passes through the diaphragm at a threaded joint, making a relatively gas-tight assembly; a hole drilled through *F*, and an opening into the tube inside the diaphragm, *D*, is provided to introduce propane gas into the assembly through the pipe connection, *H*, from a constant pressure tank. Flexible electrical connections to resistors at *J* are attached to the main power bus bars.

The electrical connections for the kiln (Fig. 9) show only one phase. The 220-volt, 3-phase power supply is indicated at *A*, one line of which goes directly to the primary windings of a 40-kva., immersion-type induction transformer, *B*, which has taps on the primary side arranged to give from 12 to 16 volts on the secondary in steps of one volt each.

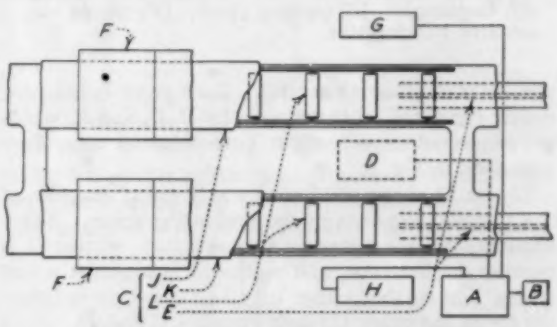

FIG. 7.—Schematic view of walking beam.

Regulation of the secondary voltage is obtained by shifting the primary voltage from one primary tap, *C*, to another by two contactors, which are electrically interlocked so that one remains in at all times. These, in turn, are regulated by a potentiometer controller, *E*, which governs the high and low auxiliary contactors, *F*. If the temperature goes above or below the potentiometer-controller setting, the contactors, *D*,

* Progress Report to be published by the Electrochemical Society.

operate to shift the voltage, respectively, to a lower or higher tap, *C*. These taps have previously been set manually by clips, *G*, at approximately the correct voltage and need not be changed except under extreme fluctuations in line voltage. The resistors, *H*, are connected in opposition, *i.e.*, on the same side of the kiln one resistor is joined to phase and the adjacent one to neutral to prevent eddy currents which would tend to heat up the shell of the kiln.

The fourteen resistors are connected in three groups (Fig. 10), each group to one phase, *A*, *B*, or *C*; the system is Y-connected and all resistors in each group are parallel from phase to neutral. Each group is independently regulated by thermocouples *C*, *D*, and *E*, which are connected respectively to potentiometer controllers described in Fig. 9.

Figure 11 shows the location and wiring diagram of the metallic elements in the preheating zones. These elements are connected in two sections; section *A* is nearest the hot zone, and section *B* is toward the end of the kiln so that either may be turned on independently of the other through switches *C* and *D*. Each section is rated approximately at 10 kw. at 55 volts, $7^1/_2$ kw. being applied in the bottom and $2^1/_2$ kw. in the sides. The temperature is regulated by potentiometer controllers connected to thermocouples that can be placed at a variety of locations above or below the beam.

(5) Pyrometric Equipment

Figure 12 shows the location of thermocouples. For experimental purposes, a potentiometer-type indicator was used to make readings at ten points in the preheating and cooling zones, where Chromel-Alumel thermocouples were used, and ten in the high-temperature zone with platinum-platinum 10% rhodium thermocouples. An 8-point potentiometer recorder was used to compare temperatures at various locations in the hot zone, and a 4-point recorder was used to study the heat gradient and heat differential in the preheating and cooling zones. In addition, three single-point potentiometer-recorder controllers were used for temperature-control purposes (these are described in detail in conjunction with the temperature control, p. 233). A commercial installation probably would require only 3 single-point recorder controllers with thermocouples (as shown in Fig. 10) and a portable indicator to check various points in the kiln.

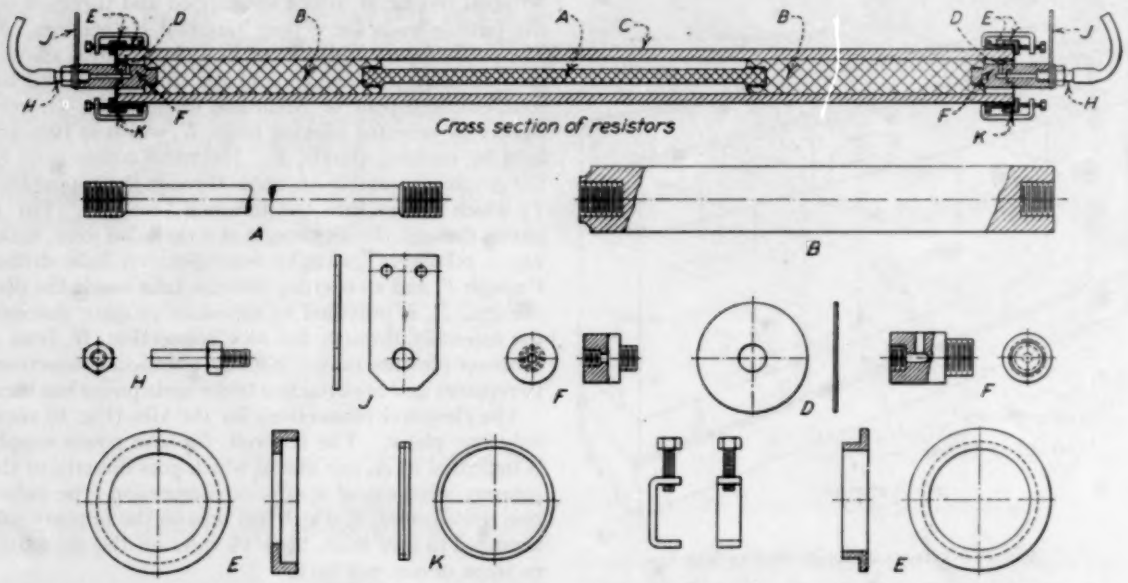

FIG. 8.—Description: (*A*) carbon rod; (*B*) graphite terminal block; (*C*) clay-bonded silicon-carbide tube; (*D*) diaphragm; (*E*) packing gland; (*F*) copper bar; (*H*) gas inlet pipe; (*J*) flexible electrical connection; (*K*) asbestos packing ring.

(6) Loading Slabs

Ware was transported through the kiln by clay-bonded silicon-carbide slabs (Fig. 13). These slabs are the tongue-and-groove design so that in the operation of the kiln one continuous tight floor is provided.

(7) Atmospheric Control

A schematic layout of the atmospheric control is shown in Fig. 14 (p. 229).

III. Operation of the Kiln

(1) Difficulties Encountered in Starting the Kiln

As might be expected, troubles were encountered in putting into operation a kiln of such radical design, with the use of a new type of resistor causing further complications. Even though the resistors had been tested and the tunnel kiln was constructed under the supervision of experienced engineers, difficulties, both mechanical and electrical, were anticipated, which is the usual experience in such an enterprise. It is gratifying to note that although some of these difficulties

proved to be even more troublesome than was foreseen, the tunnel kiln was brought to a satisfactory operating condition with only minor constructional changes.

Because it is believed that such troubles are always of interest and of possible value, they are described under the following headings: (1) resistor troubles, (2) high heat loss, (3) mechanical difficulties, and (4) slab breakage.

(*a*) *Resistor Troubles:* Before discussing the resistors, it might be explained that when the kiln was designed the proper heat balance was practically unknown, and it was difficult to estimate the amount of heat which would be recuperated from the cooling-down ware for the preheating ware. Previous tests on periodic kilns had given no indication as to the power consumption

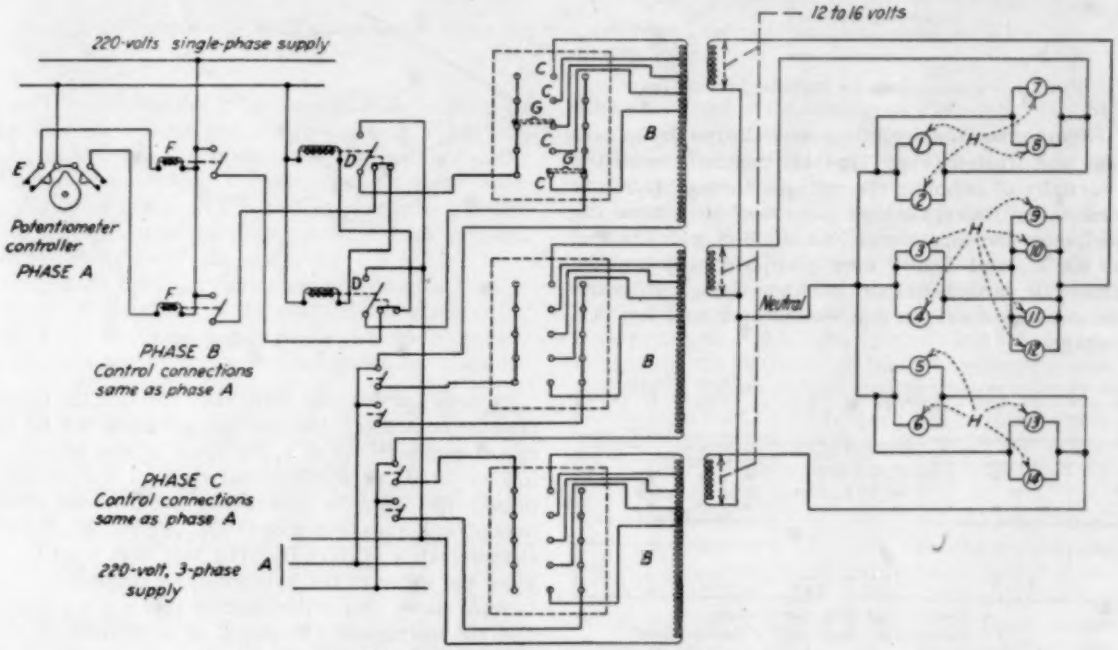

FIG. 9.—Diagram of control connections.

required, and inasmuch as two 40-kva. transformers were at hand, a third was purchased with the hope that the total capacity of 120 kva. would be sufficient to bring the kiln to the proper temperatures. Further heat (40 kw.) was supplied in the preheating sides and bottoms, which would bring the total possible input into the kiln to 160 kw. without overloading the existing equipment.

The kiln was completed and put into operation on August 12, 1937. Because the electrical layout was designed to use either the comparatively high-resistance recrystallized silicon-carbide bars or the low-resistance, graphite elements, the transformer equipment was connected as shown in Fig. 15. A 220-volt, 3-phase, multiple-tap transformer was used to regulate the primary voltage on the 40-kva. kiln transformers, which gave 80 to 210 volts in 25 equal uninterrupted steps on the secondary. The secondary from this transformer was passed through a 3-phase booster to the kiln transformers which gave approximately 10 to 22 volts at the kiln in 25 equal steps. Figure 16 shows the automatic temperature regulation obtained by the automatic voltage change through the control units. In case recrystallized silicon-carbide bars were to be used, it was planned to regulate the voltage on these bars directly from the multiple-tap transformer to control the temperature and to compensate for changes in resistance which are common to this type of element.

In previous work on the graphite resistor, propane gas had been used as a protective atmosphere around the graphite inside the protection tube. Some successful experiments had been made by substituting nitrogen for the propane gas, although a much shorter life with more varying results was obtained. It was thought that this difficulty was due to the fact that the nitrogen supplied had not been entirely dry or freed from traces of residual oxygen and that proper treatment of this gas before putting it into the tubes would result in a practical means to control the graphite-resistor oxidation. The use of nitrogen in place of propane apparently had an advantage in that the graphite assembly was easily removed from the protection tube. When propane was used, there was a definite sealing

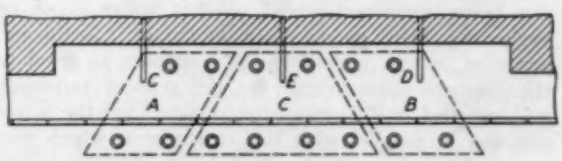

FIG. 10.—Grouping of heaters and thermocouples.

effect caused by the cracking of the gas and the deposit of hard carbon between the terminal block of the assembly and the tube. If failure occurred in a resistor so treated, there was always difficulty in removing the assembly quickly, although this was possible by exposing the graphite to air for a time and by permitting the hard carbon to burn out.

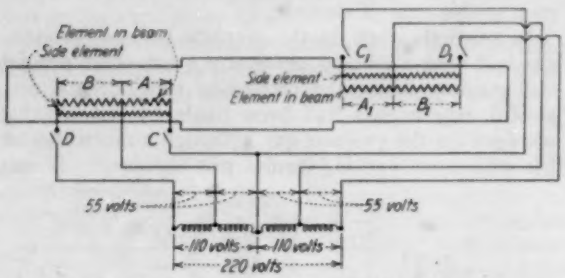

FIG. 11.—Connections for metallic heating units.

Nitrogen was obtained (commercially) as dry as possible and treated (Fig. 17); this treatment consisted essentially of bubbling the nitrogen through H_2SO_4 to remove the water, through glass wool to remove the acid, over fine copper wire (No. 40 B. S. gage) heated to 600°C, and finally over phosphorous pentoxide. This cycle, carried out four times, was thought to reduce the amount of oxygen and water vapor to a low percentage.

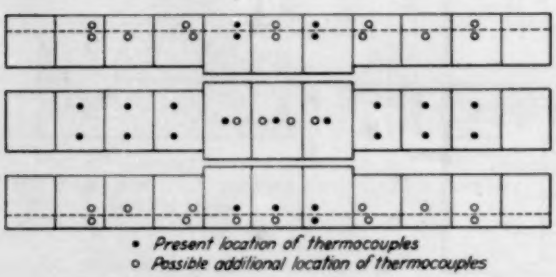

FIG. 12.—Location of thermocouples.

In starting the kiln, it was surprising to note that oxidation of the graphite resistors took place rapidly and that the average life did not exceed 80 to 100 hours. This period was much shorter than previous tests had indicated, and it was believed that either the nitrogen was being improperly dried or that water vapor or oxygen was being picked up in the circuit. In this experiment, a new hydropressure controller to regulate the pressure automatically at the resistor terminals was installed, and examination showed that the nitrogen was in parallel with this instrument, which was essentially a drum floated in a basin of water. The nitrogen gas was first carefully dried and then partially resaturated with water vapor which caused the rapid oxidation. This difficulty was overcome partially by covering the surface of the water with oil, but the resistor-assembly life was still too short to be practical for commercial use. Supplying the dried nitrogen directly to the resistors to eliminate the hydropressure controller did not lessen the difficulties much, and the use of nitrogen was discontinued because of the excessive quantities of gas required to maintain a positive pressure within the resistor-assembly tube.

The use of propane as a protective atmosphere was resumed because this method had indicated that a long life could be obtained. Inasmuch as gas had been supplied at high pressures in previous experiments, it was thought that the resultant sealing was at least partially a function of the amount of gas which had been introduced. With better pressure-control instruments, it appeared probable that the sealing action could be delayed or so reduced in amount that the removal of the resistor from the protection tube would present no insurmountable difficulties.

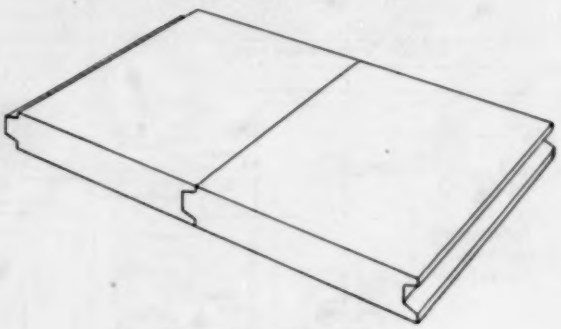

FIG. 13.—Loading slabs.

Propane gas was then introduced through the hydropressure controller; because this gas could not be obtained commercially in a dry form, it was treated as follows: the gas was bubbled through sulfuric acid, passed over Drierite (anhydrous $CaSO_4$), and finally over phosphorous pentoxide (P_2O_5) (see Fig. 18, p. 230). Orthotoluidine ($C_6H_4 \cdot CH_3 \cdot NH_2$) was also used to replace the water in the hydropressure controller. The formula shows that orthotoluidine contains no oxygen, and the instrument functioned as accurately as with water because the specific gravity and viscosity of the orthotoluidine are close to those of water at ordinary temperatures.

The first experiments in introducing the propane gas in this manner resulted in a peculiar pressure condition within the resistor assembly. The primary objective was to reduce to an absolute minimum the amount of this gas necessary to hold a slight increase in pressure inside the tube over that of the kiln. Regulating the instrument to supply 0.02 to 0.05 in. water-gage pressure to the resistors quickly resulted in a pressure condition inside the tubes of about 0.2-in. water-gage pressure over that of the kiln. This condition was misinterpreted as being due to the fact that the propane gas was increasing in pressure, due to temperature, thus causing a back pressure in the instrument. At first, this seemed to be a fortunate condition because the amount of propane used for the 14 resistors was negligible, but after a few hours, the resistors failed from oxidation almost faster than they could be replaced. Investigation indicated that the increased pressure

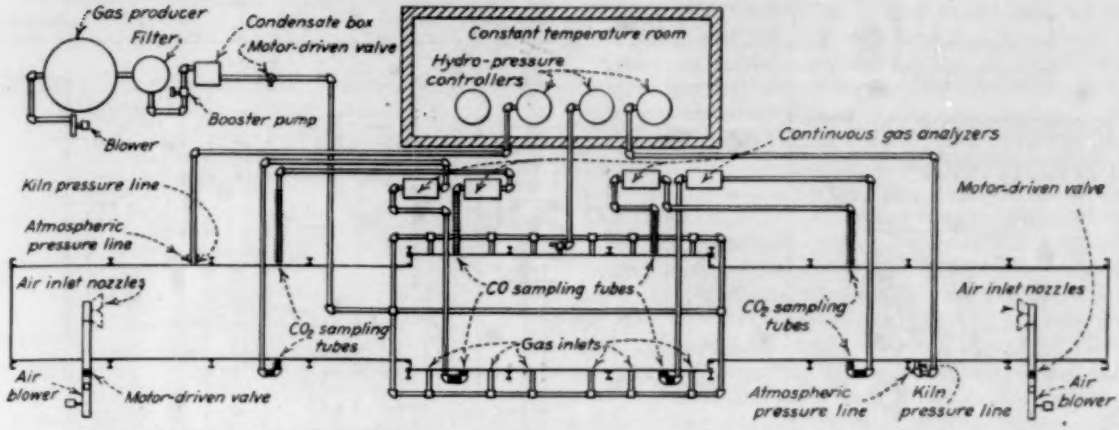

FIG. 14.—Schematic diagram of atmospheric and hydro-pressure control of kiln; motor-driven valves are hydrocontrolled.

within the tube was due to the oxidation of the graphite caused by air leakage in through the tube which produced an enormous increase in pressure because of the change in graphite from the solid to the gaseous state. The difficulty was overcome by increasing the pressure at the instrument to the point where no back pressure from oxidation could take place.

The results obtained were more encouraging than in previous trials, although the resistor life was still far short of that obtained in previous resistor-development experiments, and an increase in resistance due to oxidation was still noted. Examination indicated that the passage of the gas through sulfuric acid was the source of trouble. Although the sulfuric acid probably freed the gas of some water vapor, the propane was saturated with acid vapors, which are more of an oxidizing agent than the water vapor itself. The removal of the acid-bubbling bottles and the control of the pressure at the resistor assembly to 0.15-in. water-gage pressure overcame the oxidation difficulties in the resistors so that their life has been increased to what is believed to be a commercial figure. Present failures are still due to oxidation, but they are greatly postponed. The low pressures used (0.15-in. H_2O gage), which are still not the minimum, apparently reduced the sealing of the graphite assembly into the protection tube, and the removal and test of the resistors at 1000- and 1500-hour periods indicated that these either were free or could be jarred loose, especially after they were opened to air for short periods.

Passing the propane gas over $CaSO_4$ and P_2O_5 is also known to be a cause of oxidation, *i.e.*, the removal of water vapor by the P_2O_5 causes the formation of phosphoric acid according to the reaction $P_2O_5 + 3H_2O = 2H_3PO_4$. This phosphoric acid is vaporized to a certain extent by the passage of a gas over it so that the propane gas entering the resistors is partially saturated with these vapors, which are quite high in oxygen.

A better method to dry propane will further increase the resistor life. The failure to recognize the importance of this problem in time complicated this work and the interpretation of results.

Coincidental with the difficulties caused by the oxidation of the resistors, it was noted that the resistors, as designed, apparently fitted neither the existing transformers nor the kiln. The diameter of the resistor bar was $1^1/_4$ in., which made possible a maximum output per resistor of only 6.5 kw.-hr. This amount of heat was too low to permit a temperature of more than 660°C to be reached in the kiln. These rods were removed, and $1^1/_2$-in. diameter rods were installed. With this size, however, the existing transformers were overloaded with current in respect to voltage and permitted a safe loading of only 7.5 kw.-hr. Because of this transformer condition, 4 elements were removed and replaced with 4 recrystallized silicon-carbide bars, 34 in. long and $1^1/_4$ inches in diameter, each rated at $11^1/_2$ kw. These were placed and connected directly to manually operated voltage regulators (Fig. 19) to control the temperature and to compensate for their resistance increase. The remaining 10 graphite resistors were rephased so that they could be loaded to their designed capacity of 10 kw.

The silicon-carbide bars caused difficulties because it was apparently hazardous to place this type of element in a horizontal position underneath the charge where it passed through the walking beams and center wall of the kiln. Evidently operating in a confined space at high temperatures caused these bars to sag, and their

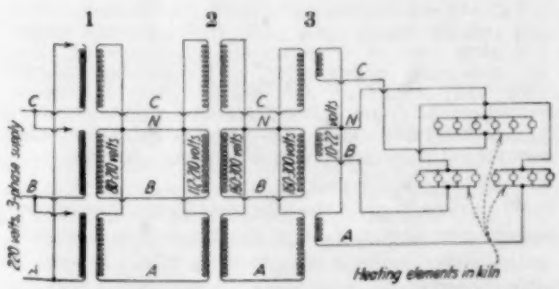

FIG. 15.—Schematic diagram of original electrical setup: (1) 25-step tap transformer: 132 kva., 220-volt primary, 80- to 210-volt secondary; (2) voltage booster: 132 kva., 112- to 210-volt primary, 160- to 300-volt secondary; (3) resistor transformers: 40 kva. (each), 302 volts primary, 22 volts secondary.

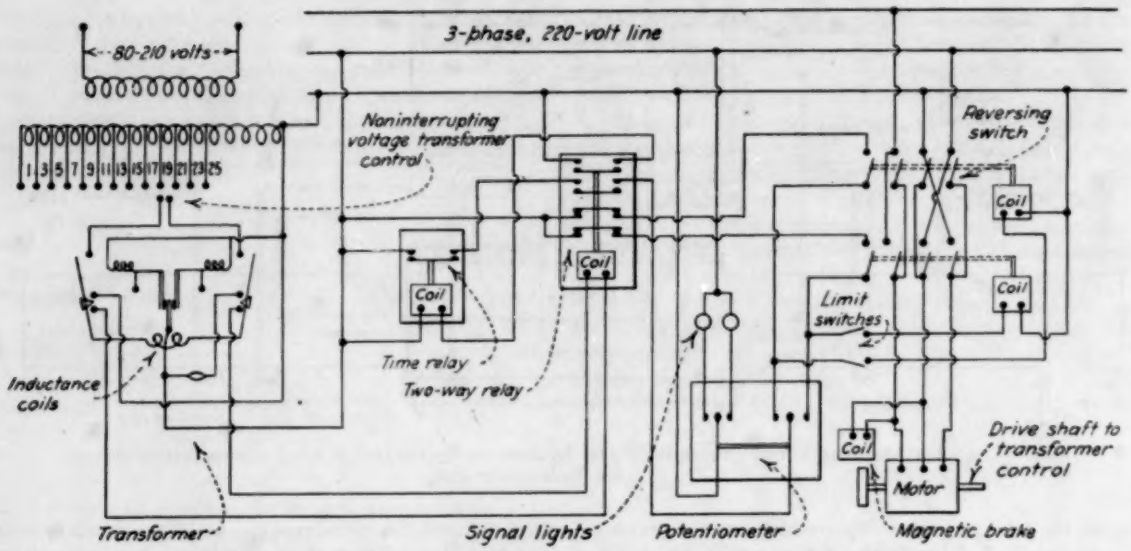

FIG. 16.—Wiring diagram of original automatic temperature-control mechanism.

removal was difficult. The use of this type of element also seemed to be dangerous because the breakage of a bar might permit pieces to fall between the walking beam and side wall of the kiln which would cause a wreck. Furthermore, in an electric kiln operated under reducing conditions, changing a bar would upset the atmospheric conditions in the kiln during its removal (even though the sagging could be overcome by providing a support for the bottom).

In order to use all-graphite resistors, their design was changed to fit the existing transformer equipment, *i.e.*, to increase their resistance so that they could be used to the full capacity of the transformers without overloading them with current. A reduction in the size of the bar to make this increased resistance possible was impracticable because of the extreme fragility of such a bar, which would be only 0.7 inch in diameter. The idea of making the bars star-shaped (Fig. 20) was tried. This resistor worked reasonably well, although the difficulties encountered were attributed to lack of mechanical strength. Failures on this bar were due chiefly to breakage, if the kiln were cooled down to any extent, or to any mechanical shock to which it was subjected, either inside or outside of the kiln. It was possible, however, to reach cone 13 with good heat distribution, which at least indicated that the 120-kw. maximum power input would be sufficient to obtain the desired results. The experiments with this resistor were complicated further by trouble with the walk-

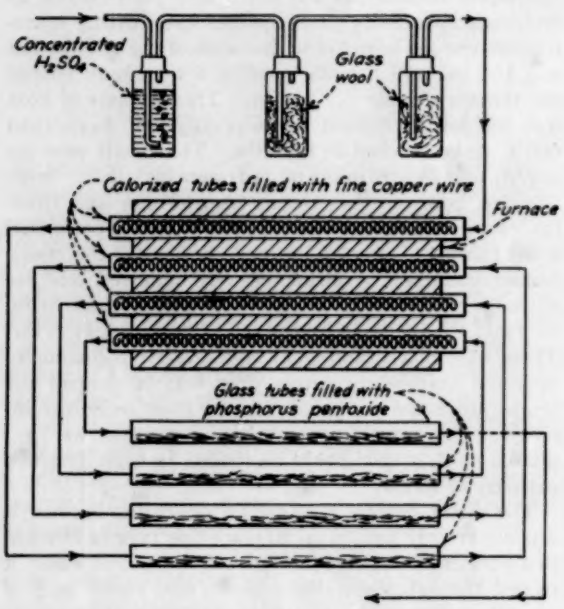

FIG. 17.—Method of drying gas.

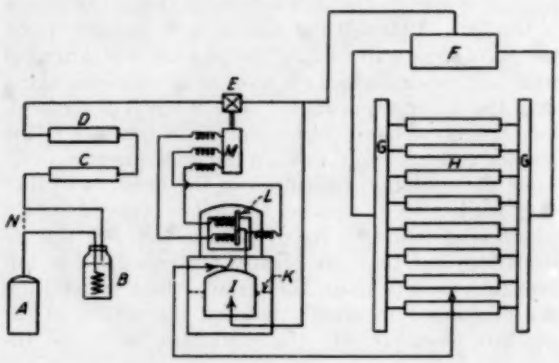

FIG. 18.—Gas-pressure control for heating units: (*A*) propane supply tank; (*B*) H_2SO_4 bubbler bottle; (*C*) glass tube of Drierite; (*D*) glass tube of P_2O_5; (*E*) motorized control valve; (*F*) equalizing pressure tank; (*G*) manifolds; (*H*) heater tubes; (*I*) hydrorecorder float drum; (*J*) differential pressure chamber; (*K*) orthotoluidine level; (*L*) high-low contactor; (*M*) control valve motor; (*N*) bubbler bottle by-pass.

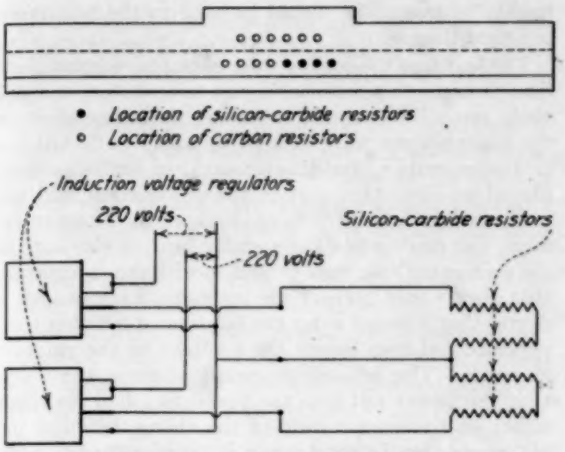

FIG. 19.—Diagram of recrystallized silicon-carbide resistor connections.

ing beam in which the lifter blocks shifted and, in part of their movements, actually contacted the tubes, giving them a severe mechanical shock. Until this was discovered, the breakage of the bars was blamed upon their low mechanical strength.

With a comparatively few known facts, it would have been possible (1) to construct the kiln and figure its heat requirements, (2) to design the resistors to fit these heat requirements, and (3) to specify the transformers to fit the resistors. Because these facts were not known at the time the equipment was purchased and because an experiment of this type has more value if the resistors, etc., are made to run in spite of adverse conditions, no radical change was made in the equipment. The resistor development, however, was important enough in this experiment to warrant the use of a medium-strength bar under fairly reasonable load conditions and to rebuild the kiln transformers to give the correct power input for this type of bar. This was done as described under "Resistors and Electrical Connections" (p. 224) so that properly designed resistors could be used.

The change in coils on the transformers permitted the use of 14 graphite resistors without overloading the transformers. Inasmuch as the number of resistors was fixed by the design of the kiln, proper attention could not be paid to the best electrical loading of the resistor by taking into account the correct current density, wattage dispersion, etc.

One of the desirable features of the graphite resistor is the property of constant resistance as long as its cross section remains unchanged, *i.e.*, there is no chemical breakdown which affects its electrical properties. The necessary equipment to regulate voltage on a heating element whose resistance changes with time is an item of considerable expense; in rebuilding the transformers, therefore, this property of constant resistance was used to advantage (see "Resistors, etc.," (p. 224)). This made possible the removal of the multiple-tap transformer (see p. 227 and also Fig. 15). Transformers, similar to the type that was rebuilt, are comparatively inexpensive, and the authors believe that a considerable reduction in the initial cost of an electric-kiln installation is indicated.

Under the conditions described, the behavior of the resistors has been satisfactory. The average life, even under the severe conditions of the test, appears to be 2000 hours. At the end of the test, the average life was calculated, although 8 of the original 14 bars were still in service and in good condition. The failures of the other bars were caused primarily by power failures which cooled the kiln and caused the terminals to part. These, in turn, failed to reëstablish electrical connections. In these cases, all of the bars were of their original diameter and were not oxidized. This was not true of the terminals, some of which were oxidized about one-half their length, at which point they were apparently hot enough to unite with the residual oxygen and water in the propane. Evidently a larger tube and better gas conditions would have prevented this breakage. With better gas conditions as well as with proper electrical loading, this life undoubtedly can be raised so that a reasonable average (at least 4000 hr.) may be anticipated under intelligent operation and handling of the kiln. The cost of the propane gas appears to be under 1 cent per resistor per 24 hours. No water cooling is required so that this source of annoyance and difficulty has been discarded.

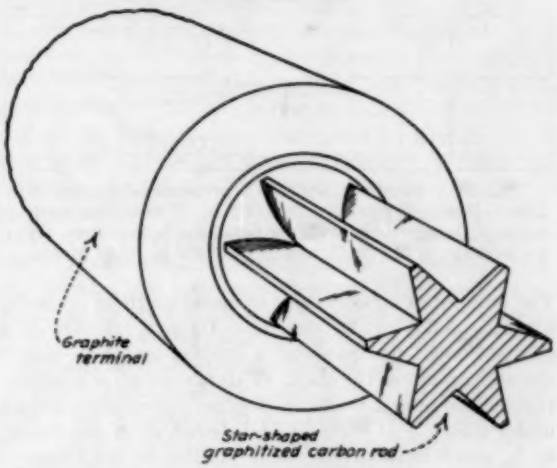

FIG. 20.—Resistor.

(*b*) *High Heat Loss:* One of the primary considerations in the kiln design was to provide ample opportunity for the charge to cool. This problem was expected to give the greatest difficulty because (owing to the short length of the cooling zone) both the ware and the carrier would come out so hot that they would be ruined. Accordingly, the cooling sides of the tunnel were provided with ducts for the escape of heat and were also constructed with very thin fireclay refractories so that the temperature of the charge would drop rapidly (Fig. 1, section *C-C*, p. 222). When the kiln was started with all the power available at that time, a temperature of only 660°C could be reached in the hottest section. The top and sides of the kiln became so hot that the steel shell began to buckle.

The heat escaping from the shell apparently came from (1) the cooling ends of the tunnels and (2) through the numerous fireclay shapes, which were provided to measure temperature and type of atmosphere, determination of pressure, etc. Opening the doors revealed that the top of the kiln apparently was under positive pressure and that there was a strong draft into the kiln along the bottom. The kiln, therefore, was shut down, and baffles were spaced at various intervals in the cooling and preheating zones (Fig. 1 (*O*)). The space between the inner lining and the shell of the hot zone as well as the cooling side of the tunnels was filled in with diatomaceous earth, and the high heat-conducting fireclay shapes were replaced as far as possible by refractories of a better insulating value. Air pressure was also applied at both ends of the kiln to maintain a positive pressure of 0.002 in. water gage in the bottom of the walking beam in the hot zone, which placed the entire kiln under pressure.

Heating under negative pressure conditions obviously is not as satisfactory as under a positive pressure. The arrangement of the apparatus (Fig. 14) maintained pressure conditions in the kiln as shown in Fig. 21.

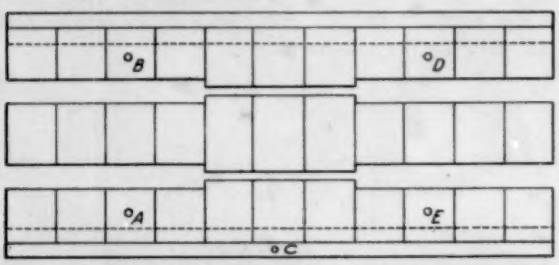

FIG. 21.—Points at which air pressure is measured in kiln. Note: A pressure of 0.002 in. H_2O at the control point, *C*, beneath the walking beam in the hot zone, gives an average at *A*, *B*, *D*, and *E* of 0.022 in. H_2O pressure.

The amount of air necessary to maintain these pressures averages 8375 cu. ft. per hr. Air put into the kiln escaped when the doors were opened and also seeped through cracks in the shell. This air pressure is advantageous not only to maintain positive pressure conditions, under which heat transfer and distribution are apparently much better controlled, but also to help remove moisture and carbon from the ware being fired. Theoretically, about 5 to 6 kw. would be necessary to heat this amount of air. No reduction in the kilowatt input into the kiln was gained by cutting off the air supply; this apparent discrepancy may be accounted for in one of two ways, *viz.*, (1) more heat from the cooling-down charge was recuperated to the heating-up ware before passing out into radiation from the steel shell or (2) the heat was held in the bottom, *i.e.*, in the walking beam, by a positive pressure.

These changes, applying pressure and adding insulation, naturally made an enormous difference in the power input of the kiln. At the same time, it indicated two important facts, *viz.*, (1) that the major portion of heat put into the kiln eventually would find its way out in the form of radiation and convection from the shell and (2) that in building an electric kiln the best quality of insulation should be used to the maximum practical thickness.

The fear that the cooling ware would have insufficient time to come to a reasonable exit temperature was entirely groundless. In fact, holding the temperature of the cooling-down ware as high as possible effected the best recuperation, and this temperature limit therefore played an important part in the power consumed per unit of ware. An interesting check on the latter statement was made when the metallic heating elements in the preheating zone were turned on with the expectation that they would preheat the incoming ware to such a degree that it would enter the hot zone at a higher temperature and thus reduce the loadings on the graphite elements. The astonishing result of these trials was that the power put into the preheating had no effect either on the temperature of the charge entering the hot zone or on the total power input into the hot zone. In other words, the 40 kw. put into the preheating elements had no appreciable effect upon the temperature of the preheating ware and simply added this amount to the power input. In this case, the differential in temperature between the cooling-down and the preheating ware was minimized so that little or no recuperation was taking place. By using the metallic preheating elements, the temperature of the heating-up ware on some schedules actually exceeded that of the cooling-down ware so that heat was being transferred from the warming-up charge to that in which the temperature was dropping. Despite this fact, the exit temperature of the ware was not excessive, proving further that cooling through the shell, even when it has been fairly well insulated, is easily accomplished.

(*c*) *Mechanical Difficulties:* The walking-beam type of kiln is not new; new features, however, were used in this installation, *viz.*, the two walking beams provided in the same tunnel to move the ware in opposite directions. These two walking beams were powered from the same unit, and their movement was such that heating elements could be passed through them. A simple arrangement (described on p. 224) was designed and put into operation with no more difficulty than would be expected normally from a machine of this type. Before the beam was properly adjusted to operate at the comparatively high temperatures, difficulties were noted in a so-called "shuttle" of the beam. It would suddenly reverse its movements and disturb the position of the slabs on the kiln shoulders so that these had a tendency to go through the kiln at an angle. Proper adjustment of the valves and movements eliminated this trouble.

After the kiln had been operating at cone 13 successfully for a time, the resistors in the bottom of the kiln had to be replaced frequently (as mentioned before); an examination of the rods showed that they were broken. This condition existed for several weeks until finally the protection tubes began to break at a point where they passed through one of the walking beams. Examination showed that the lifter blocks had shifted on the beam. A shutdown was necessary, and the source of the trouble was traceable to two conditions as follows:

(1) A too-thick mortar bond had been made where the lifter blocks keyed into the bottom of the beam; the cement had become soft and permitted the blocks to slide.

(2) The clay-bonded silicon-carbide slabs used to convey the ware had exuded a glaze which was thought to come from the bond. Examination of the beam in the hot zone showed that this glaze had run down in globules between the walking beam and the kiln wall. There were indications, furthermore, that the slab actually had a tendency to stick to the walking beam at the ends of the hot zone where the exuded glaze started to cool off. A combination of these circumstances eventually caused part of the blocks to shift where actual contact was made with the kiln wall, thus aggravating the condition to the point where several of the blocks were broken.

These defects were overcome by more careful workmanship in the kiln construction and by painting the silicon-carbide slabs on both sides with alumina.

(*d*) *Slab Breakage:* Because of the short length of the kiln, the comparatively high temperatures, and the fact that most of the heat was to be supplied underneath the charge, trouble with the slabs was anticipated, and a silicon-carbide slab of minimum clay bond was specified. Difficulties were encountered, even while the kiln was running at a temperature of only cone 9. The slabs began to crack in the middle, parallel to the long axis of the kiln, after the third to the fifteenth cycle. This condition became so serious that it was impossible to keep enough slabs on hand to run the kiln continuously. An examination of the broken slabs indicated that these had not been properly fired; a dark core was noted among those which were cracked, whereas the color was a dark, even gray in the center of slabs which did not fail. Replacement of slabs with slabs of slightly different mixes containing progressively more clay bond corrected this fault with a consequent increase in slab life to about 80 to 100 cycles.

At the time the kiln was built, a brick baffle was placed in the walking beam to protect the metallic elements in the preheating sides from the excessive heat of the hot zone, which was thought to be higher than this type of element could safely stand. The cracking of the slabs was aggravated probably by the presence of this baffle, inasmuch as the slabs would be placed suddenly over the high temperatures in the beginning of the hot zone. The removal of the baffle (after it was found that the metallic elements were unnecessary) immediately confirmed the suspicion that at least part of the cracking came from this source. Although time did not permit an actual check, the extremely fast schedules also had a detrimental effect upon slab life.

The slabs, as originally designed, were provided with a tongue and groove (Fig. 13), which was thought to be necessary because the cracked slabs in the kiln conceivably would be carried out by the tongue and groove of the members on either side. Although many slabs cracked in service, they were brought safely out of the tunnel. The manufacture of the tongue-and-groove slab is expensive, and the use of a plain slab (without the tongue and groove) would result in a price reduction of at least 30%. Several slabs of this type, therefore, were tried and disastrous results were quickly noted. The breakage of one piece caused a bad wreck, so that further experiments with plain slabs were discontinued. A high clay-bond mix seemed to be the most satisfactory to prevent loss from cracking. This type of slab, however, had no great mechanical strength, and after a few trips through the kiln, the tongue and groove became so badly chipped that they could not be recommended. In view of these results, it seemed best to specify clay-bonded silicon-carbide slabs for definite temperature and service conditions, the silicon-carbide content probably not to exceed 80%. The manufacturer should also provide the bond with sufficient refractoriness so that there would be no tendency for glaze to exude from the surface.

(2) Temperature Control and Distribution

Under the electrical-control system (see "Resistors and Electrical Connections," p. 224), tests were made by placing cones at various heights in the charge and at various intervals over the 24-hour period. By regulating the top and bottom heat, even temperature conditions were maintained throughout the kiln over extended periods. The resistors were grouped, not with the top and bottom separately, but as shown in Fig. 10, and even temperature conditions in the top and bottom were determined to some extent by the trial-and-error method. With an excessive heat above and a light heat below, the size of the upper resistors would be slightly decreased and the lower ones increased a little. In a larger installation, provisions might be made for operating the top and bottom separately, so that this condition could be automatically controlled easily. By increasing the sensitivity of the 3 recording potentiometers to the maximum point, the heat-control system (regulating the power input between a high and a low tap) maintained a heating curve which showed no visible variation. The heat control possible with this type of installation greatly exceeds the sensitiveness of the average-type controller, and the regulation possible is far more sensitive than is necessary to fire even the most delicate ware. Occasional very high- or very low-line voltage conditions, which in this particular installation varied from 210 to 250 volts, necessitated the manual setting of the transformer taps if, for example, either the high or low tap was still maintaining conditions which were too hot or too cold within the kiln. The load factor of the kiln has been found to average at least 85%. In a new installation, where line-voltage variations would not be so excessive and where contactors of sufficient size to carry heavier currents would be provided, the load factor should be even higher. The load factor is extremely important from the standpoint of the power supplier, and it is one of the main features which make this type of load extremely attractive and thus obtainable at a reasonable price.

(3) Atmospheric Control

In the United States, reducing atmospheres are used to advantage to manufacture spark plugs, whereby it is

reported that blisters are prevented and the mechanical and dielectric strengths are better than if the porcelain were fired under oxidizing conditions.[35]

Experiments in firing ceramic ware under reducing conditions and the manufacture of a suitable reducing atmosphere have been recorded.[33] To make a translucent, vitreous ware with a minimum of difficulty, it was formerly believed that reducing atmospheres should be introduced into the kiln just before vitrification. The presence of these reducing gases prevented overfiring so that vitrification could progress beyond the

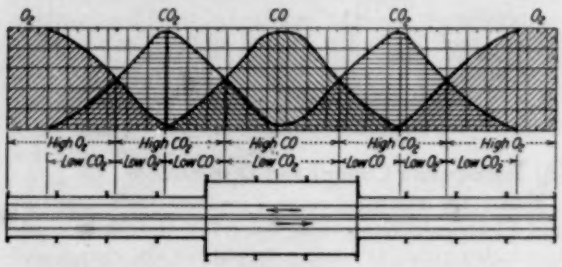

FIG. 22.—Desired kiln atmosphere under reducing conditions.

normal overfiring temperature under oxidizing conditions, thereby permitting the formation of sufficient glass within the body to transmit light through it. These earlier experiments indicated that, under oxidizing conditions, overfiring would result in a majority of cases before this increase of vitrification could be reached. The usefulness of reducing atmospheres to manufacture hard porcelain has usually been attributed to the action of these gases upon iron compounds in the body, which resulted in a white ware. There are indications, however, that this effect is secondary and that prevention of overfiring was the main advantage which necessitated its use. It was noted with much surprise, therefore, that ware fired through the tunnel kiln at temperatures which in the periodic furnaces had produced overfiring (temperatures at which translucency of a sufficient degree could be obtained) did not show overfiring. This phenomenon was attributed to the fact that previous experiments had been run in furnaces heated by recrystallized silicon-carbide bars which at the maximum temperature had a wattage dispersion of 86 watts per sq. in. Heating under lower wattage dispersion conditions, *i.e.*, a lower differential in temperature between the resistors and kiln walls and the ware, apparently increased the range of these bodies by $1^1/_2$ to 2 cones, permitting their successful firing under oxidizing conditions.

Because the kiln was equipped to run under reducing conditions and because a controlled atmosphere in the firing operation is one of the possible advantages of electric heating, experiments were conducted to test the feasibility of the introduction and control of a reducing atmosphere during the firing operation (see Fig. 14 for this installation). The procedure, which was tested in periodic installations, has been recorded.[33]

[35] Report by H. F. Royal, Champion Spark Plug Co. (letter from F. H. Riddle, May 18, 1937).

As previously mentioned, the only effect of reducing atmospheres on a ceramic body takes place just before vitrification. The presence of excessive amounts of water vapor, soot, or other impurities is harmful if this reducing period is carried through the soaking and cooling time, because the carbon apparently deposits in the body or glaze, causing black or brown spots. A clean reducing atmosphere apparently has no detrimental effect and may be maintained after vitrification has taken place through the soaking period and into the cooling time if the oxidizing conditions are reinstated before a temperature of 500°C is reached. Below this point there is danger of explosion.

Arrangements were made to divide the tunnel-kiln atmosphere into oxidizing, neutral, and reducing zones, which would be common to preheating and cooling sections alike (see Fig. 22). This scheme permits ware to be fired under reducing conditions without interfering with the recuperation principle or the common hot zone and without the necessity of dividing the two tunnels, which would cut down heat transfer. The manufacture of the reducing gases was carried out as shown in Fig. 14. Compressed charcoal tablets (Charkets) were burned in a small producer of the conventional type. These Charkets permitted the manufacture of satisfactory gas without excessive amounts of fuel, probably because of their peculiar burning action in which combustion apparently takes place through the whole tablet and thus maintains a temperature of over 900° within the piece itself. At this point, according to the equilibrium curve, carbon monoxide is the major product of the combustion of carbon (see curve in Fig. 23). By the use of charcoal tablets, furthermore, the fuel consumption for a given richness of gas not only is much lower than with other types of fuel, but the temperature of the producer is such that no difficulties are encountered, either with the grate bars or the refractory lining.

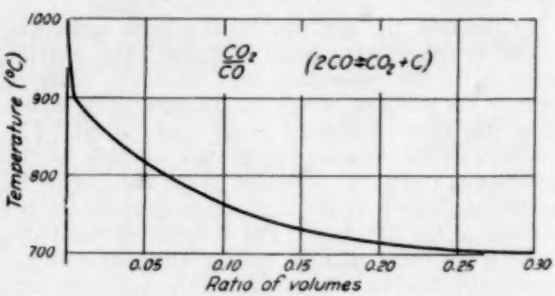

FIG. 23.

Experiments in using a reducing atmosphere were successful from the start (see the arrangement in Fig. 14). In this installation, an average of 450 cu. ft. of gas per hour, analyzing 35 to 40% CO and 2 to 5% CO_2, was introduced at the gas inlets. The average analysis, obtained under the best conditions, was 15% CO in the hot zone and 18% CO_2 between the oxidizing and reducing zones. The ware fired under these conditions was satisfactory and a good white color. The temperature maintained in the kiln was approximately one

cone higher than that considered maximum under oxidizing conditions.

Although vents were provided in the original construction for the escape of the products of combustion between the carbon monoxide and air, these were not used and apparently were unnecessary; evidently enough seepage was provided through the shell.

One interesting development observed was that there was an immediate reduction of about 30% in the power input necessary to maintain given temperature conditions. This was obviously due to the combustion of the carbon monoxide, although no flames could be observed in the hot zone. This reduction in power input did not actually affect a material saving in cost because of the expense of the gas manufactured from the charcoal tablets, which in turn might be traced to the high cost of the Charkets ($28.00 per ton). Temperature regulation with reducing conditions was not as constant as that under oxidizing conditions; the variation was about ±20°C, probably due to the burning of the gas.

From these experiments, it was apparent that a reducing atmosphere, if desired, could be maintained easily in the electric kiln.

(4) Schedule, Temperature, and Loading

Inasmuch as one of the primary objectives of the continuous-kiln experiment was to determine the possibility of using electricity in competition with other types of fuel, power consumption per unit weight of ware was the first consideration. It was obviously impossible, with laboratory facilities, either to make or to dispose of the amount of ware which could be fired even in this small installation; the slabs therefore were loaded with fire brick to represent definite weights of charge, and ceramic ware (see Part III, p. 214 and Part IV, p. 216) was placed either with the brick or at frequent intervals throughout the day. There appeared to be three main variables, *viz.*, loading, speed through the kiln, and temperature.

(*a*) *Effect of Load:* Experiments conducted on different schedules at a constant temperature, while varying the load from 16 to 72 lb. per cu. ft., indicated that the loading had little, if any, effect upon the power input into the kiln. The power input, in relation to loading and schedule, was still a constant so that, to obtain minimum power consumption per unit of weight of ware, the loading should be as concentrated and heavy as possible to be consistent with good results.

(*b*) *Speed of Firing Schedule:* The firing schedule speed was tested by loading the slabs at constant weights, varying from 16 to 72 lb. per cu. ft., and altering the speed through the kiln from zero to a maximum of 2.6 ft. per hr. (20 hours total firing schedule). An interesting effect observed was that the power input into the kiln at a given temperature was, to all intents and purposes, a constant, *i.e.*, the power input at cone 13 varied from 118 kw.-hr. with zero movement through the kiln to 122.4 kw.-hr. for the maximum schedule of 2.6 ft. per hr. (20 hours total), an increase of only 2.5%. It thus appears that the fastest possible schedule, consistent with good ware, should be used and that commercially designed kilns should be sufficiently long to permit rapid passage of the charge to obtain the minimum power consumption per unit weight. This condition is due apparently to two facts, *viz.*, (*a*) in an electric kiln, all of the heat input, except that heat carried out by the ware, is practically balanced by heat transfer

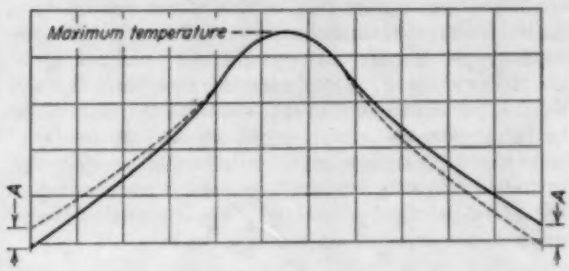

FIG. 24.—Maximum temperature differential occurs at *A*.

through the shell, and (*b*) recuperation is a function of the temperature differential between the outgoing and incoming ware at any given point, *i.e.*, the greater the differential the more the heat transfer. Obviously, on a faster schedule, the differentials would be greater so that more recuperation would take place. A typical kiln temperature-gradient curve in Fig. 24 shows the differential between the heating and cooling ware.

(*c*) *Power Input in Relation to Temperature:* The temperature inside of the kiln would obviously affect the outside shell temperature, and the higher shell temperature would increase the loss from radiation and convection, which appears to be the chief loss from a practical standpoint. An increase in inside temperature therefore would necessitate an increased power input, which was found to be the case. The relation of

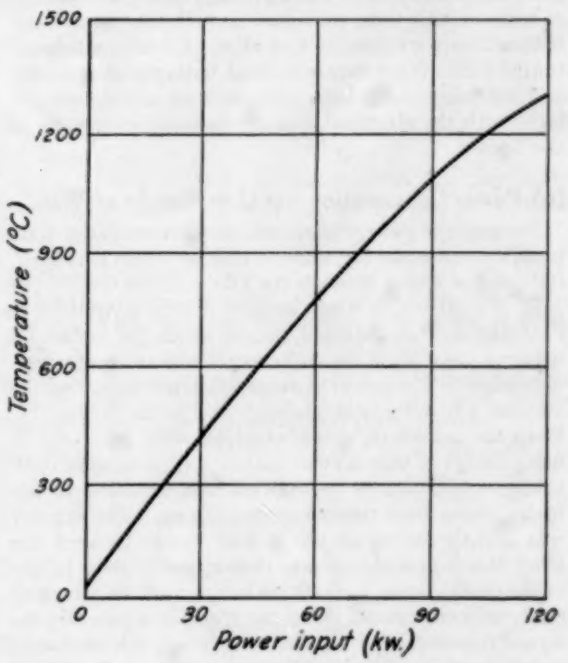

FIG. 25.

the variations in power input to temperature is shown in Fig. 25. Another obvious fact is revealed, *viz.*, that a commercial electric kiln should be so insulated that a minimum loss from radiation and convection for any given temperature is encountered.

All of the experiments were run with different loading conditions per square foot, which would not be done under average manufacturing conditions where the loading per square foot would vary according to the orders received. It appears entirely feasible that the loading per square foot in relation to each tunnel could be balanced easily, which would permit easy temperature control, *i.e.*, any given order could be split and introduced equally into each tunnel. This would give the added practical advantage of the completion of any order in the minimum amount of time.

(5) Type of Ware Fired

Most of the experiments in firing ceramic ware were run on bodies described in Parts III and IV (pp. 214 and 216). Maximum loading was considered to be that amount which can be fired practically, and such types as sanitary ware, electrical porcelain, hotel china, etc., are believed to fall under the ranges described. Representative samples of ware were obtained at different times from various factories and were fired through the kiln at temperatures ranging from cones 9 to 13. The results of these tests indicated that the charge was fired as well as under similar conditions of temperature and schedule in the modern gas-fired continuous kilns. Satisfactory results were obtained on fairly heavy electrical porcelain with the time schedule reduced at least 50%.

Interesting results were also obtained on special electrical insulating bodies manufactured by the American Lava Corporation in Chattanooga, Tenn. The results of tests on this ware indicated that it was equal to or better than ware fired in a modern oil-fired continuous tunnel kiln. The ware was fired both under reducing and oxidizing conditions, inasmuch as atmosphere affects both the electrical and mechanical properties of the bodies.

(6) Power Consumption per Unit Weight of Ware

Because the power consumed per unit weight of ware is dependent upon the temperature at which it is fired, its speed of travel through the kiln, and the weight per cubic foot at which it can be loaded, it is interesting to note the figures obtained, based upon the successful firing at cone 13 of the vitreous chinaware under consideration. The power consumptions per pound on the various schedules and loadings are given in Fig. 26. Even the maximum speed schedules were successful in firing bungs of thin service plates, a type of ware ordinarily considered to be difficult and sensitive to fire under rapid heat-treatment conditions. The quality was slightly better at the slower speeds through the kiln; this is probably due to the extremely short length of the cooling zone, a condition which could be remedied easily without cutting down the speed in a properly designed commercial-sized unit. Although it is obviously unfair to this pilot installation, constructed without previous knowledge of the main facts, to compare electric power consumption with other types of fuel, it is interesting to note that with a 20-hour schedule and a load of 72 lb. per sq. ft. (using for comparison gas at 40 cents per 1000 ft. and electricity at 5 mills per kw.), the actual heating cost is 1.323 mills per lb. for gas and 1.635 mills per lb. for electricity. The basis of comparison for gas- and oil-fired kilns was obtained from a modern gas-fired tunnel-kiln installation firing heavy ware to a temperature of cone 11 down, a temperature obviously unfair compared with cone 13.

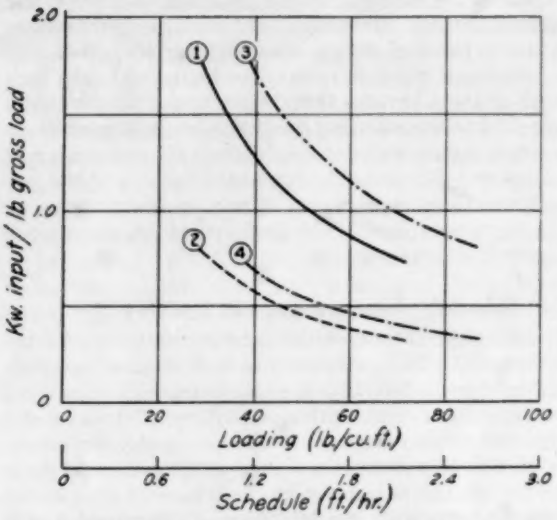

FIG. 26.—(1) 39-lb. load, and (2) 87-lb. load, speed varied; (3) 60-hr. schedule, and (4) 24-hr. schedule, load varied.

IV. Discussion of Results

Enough interesting data were obtained to warrant a discussion of the results before drawing conclusions. There are enough obvious advantages in the use of electricity for firing ceramic ware to justify experimentation, inasmuch as the electrical installation appears at least to have the good features of cleanliness, automatic control, close temperature regulation, and speed of firing under pressure conditions. It was hoped, however, that the electric kiln could meet competition with other types of fuel on an actual cost basis of installation and power consumption. The fact that power consumption is independent of loading and schedule and that a rather delicate type of ware has been fired rapidly indicates that this latter effect may be realized. The design of the pilot kiln was originally such that excessive amounts of power were required and were eventually lost in radiation. The heat-balance studies on this kiln under present conditions follow in Part VI (p. 238) of this Report.

V. Conclusions

(1) The data indicate that in areas where power costs are not excessive the electrically heated kiln probably

can be made to compete with other types of fuel on a competitive cost basis.

(2) Power input into the experimental kiln, to all intents and purposes, is a constant, irrespective of schedule and loading per cubic foot.

(3) Power input rises with increase in temperature.

(4) Top and bottom heating appear to have been successfully and practically demonstrated.

(5) It is possible to maintain heat distribution within extremely close limits, at least over the cross section in the kiln.

(6) Apparently 65% of the heat input is required underneath the charge.

(7) The use of elements in the preheating zone seems to be unnecessary as this cuts down the heat transfer from the cooling to the entering charge.

(8) The amount of recuperation is almost automatically controlled and is dependent upon the temperature differential between the cooling-down and heating-up ware.

(9) Elements of low heat dispersion are an advantage in the heating process; the figure, 20 watts per sq. in., appears to be good, although it is believed that further reduction to 5 to 10 watts per sq. in. would be advisable and the results obtained would be better; this same statement may apply also to combustible fuel-fired kilns to cut down the "toasting" effect.

(10) The graphite elements used in this installation apparently are successful from the standpoint of heating effect, constancy of resistance, and ease of control; when failure occurs they may be replaced easily and rapidly without interfering with the operation of the kiln.

(11) The load factor of 85% obtained in these experiments is thought to be good, but it can be improved considerably under better designed conditions.

(12) The total heat input into the kiln, except that carried out by the ware, eventually finds its way out in the form of radiation and convection from the shell; this accounts for the greater part of the heat.

(13) Recuperation appears to be a kind of short circuit of heat from the cooling-down ware to the heating-up charge and then to radiation from the shell.

(14) Tests have indicated that clay-bonded silicon-carbide slabs to carry the charge will last long enough that their cost per unit of ware should not be excessive.

(15) These experiments have indicated that, although the electric kiln is limited in cross section, practical sizes could be made to accommodate large pieces of ware, such as the average vitreous sanitary ware, and that larger-size kilns would be proportionally more efficient.

(16) The fact that the entire heating process can be done under positive pressure conditions appears to be an advantage of the electric kiln over the combustible fuel-fired type.

(17) Experiments with a reducing atmosphere, using different atmospheres in the preheating, soaking, and cooling zones of the kiln, apparently are successful.

(18) Because the greater part of the power input into the kiln is eventually accounted for from radiation and convection, an electric kiln should be insulated to the maximum amount with the best possible type of insulation to reduce the heat losses to a minimum.

(19) With larger-size firing chambers, the perimeter, through which heat is lost, becomes less compared to the cross section, which results in relatively smaller heat loss.

(20) Types of ware other than the vitreous china experimentally produced in the laboratory were also fired successfully.

(21) With a minimum expected life of 2000 hours for the graphite-resistor assembly, using a heavy loading and a fairly fast schedule, the cost of the resistors per pound of ware becomes negligible.

(22) One of the most important items of cost in a pilot-electric kiln consists of electrical regulation instruments and pyrometric equipment; it is necessary to have a considerable amount of this apparatus to record data and to have extra flexibility; in a commercial unit, this equipment would be much simpler and would have a lower relative cost.

(23) The walking-beam type of movement of a charge appears to be entirely practical and permits the use of top and bottom heating, which is considered to be important; the use of slabs to convey the ware through the kiln also presents the possibility of combining operations, such as finishing and kiln setting, with obvious savings in manufacturing costs; slabs offer conveying possibilities which manifestly do not apply to cars; in addition, the walking beam eliminates the relatively large amount of heat carried out by the cars.

(24) Heat balances on the pilot kiln as well as a proposed commercial installation follow in Parts VI and VII.

(25) Practically all heat put into the kiln may be recovered and used for drying and heating, especially if driers, etc., are placed over the kiln.

Acknowledgment

In the design, operation, and interpretation of results on this work, the Swindell-Dressler Corporation of Pittsburgh, Pa., acted as consultants. Figures obtained were checked by them in order to keep the experiment on a thoroughly practical basis. The authors acknowledge with thanks the good work of this Company, especially that of F. W. Brooke and Philip Dressler, vice-presidents.

VI, HEAT BALANCE ON PILOT KILN

By M. G. Toole and M. S. Nelson

A heat balance on a fuel-fired kiln is recognized as a complicated determination because it is necessary to know (*a*) composition of the fuel, (*b*) amount of excess air, (*c*) radiation and convection from the furnace, (*d*) heat of endothermic reaction for firing ware, (*e*) heat carried out by the charge, (*f*) heat carried out by the ash, etc., and (*g*) composition, temperature, and amount of flue gases.

The majority of these requirements are not present in an electrically fired furnace, whose heat balance is far easier to determine, because the heat equivalent of a given kilowatt input can be accurately calculated. The heat introduced into the kiln is disposed of as (1) heat used in endothermic reaction of firing ware, (2) heat carried out by slabs and load, (3) heat lost through terminals of heating elements, and (4) heat lost through walls of the kiln.

The heat balance given here was calculated for the pilot kiln to determine relative losses and to interpret the results in such manner that the knowledge acquired in working out the practical details of this unit may be used.

From the experimental viewpoint, it did not seem to be necessary or practical to load the pilot kiln entirely with ceramic ware. Fire brick, therefore, were used to approximate various loads on several schedules in order to study the behavior of the kiln under a wide variety of conditions, and green ware was placed only at intervals to determine its firing behavior under the schedules used.

Because the entire load may be considered as fire brick which have passed repeatedly through the kiln, there would be no endothermic reaction.

For purposes of the heat balance, a representative schedule is considered as follows:

Schedule = 24 hr.; load = 25 lb. per cu. ft. loading space; slabs = 23 lb. per linear ft.; maximum kiln temperature = 2372°F; exit temperature of load = 660°F; ambient temperature = 100°F; movement of load = 2.167 ft. per hr.

The specific heat of the clay-bonded silicon-carbide slabs is 0.18 and of the fire brick, 0.20 B.t.u. per lb. per °F.

Heat carried out by ware in both tunnels = Q_L.

Where $Q_L = \Delta t \times$ lb. ware $\times$ specific heat.

$Q_L = (660 - 100)(25 \times 2.167 \times 2)\ (0.20) =$ 12,135 B.t.u./hr.

Heat carried out by slabs in both tunnels = Q_S.

Where $Q_S = (660 - 100)(23 \times 2.167 \times 2)(0.18) =$ 10,048 B.t.u./hr.

Total heat carried out by ware and slabs =

$$\frac{12{,}135 + 10{,}048}{3412} = 6.5 \text{ kw.-hr./hr.}$$

Because it was impossible to differentiate between the heat conducted through the walls and through the heating-element terminals in the high-temperature zone, other tests were necessary to determine the heat loss from the terminals. This was done by placing two 34- by $1^1/_4$-in. diameter recrystallized, silicon-carbide heating elements with water-cooled terminals in a small furnace. By determining the kilowatt input and cooling water loss for several temperatures, it was possible to determine the heat loss through the shell for these temperatures.

After calibrating the kiln, the silicon-carbide bars were replaced by two graphite heating-unit assemblies, similar to those in the pilot kiln (Fig. 27), and the power

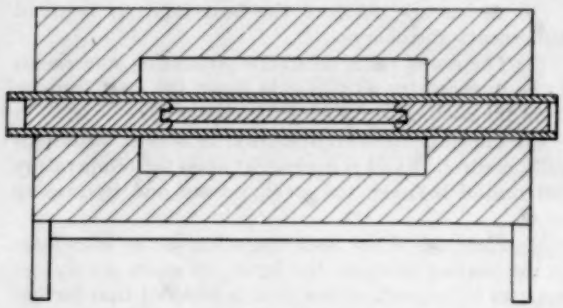

Fig. 27.

input was measured for the same temperatures as in the calibration test. The difference between the input in the second run and the shell loss in the first run represents the total terminal loss. For a temperature of 2372°F, this was found to be 1.167 kw.-hr. per hr. or 3981 B.t.u. per hr. per terminal. It should be noted, however, that the graphite terminal extended 4 in. inside the furnace wall, whereas in the pilot kiln this distance is only about 2 in. This difference in distance of the element from the inside wall affects the temperature of the terminal at a point, T_6 (Fig. 28) even with the

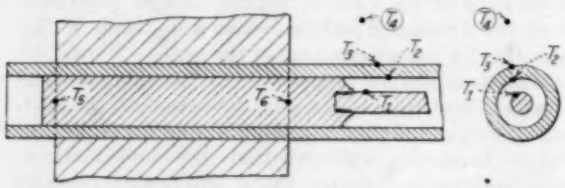

Fig. 28.

inside wall, which makes it necessary to calculate this temperature. For the calibrated kiln, this was found to approximate closely the actual furnace temperature.

To make the results obtained in the test kiln applicable to the pilot kiln or to other installations, an experimental value was obtained for the thermal conductivity of that portion of the resistor assembly which passed through the furnace wall. This part is composed of the 3-in. diameter graphite terminal and the 3-in. (inside diameter) by $4^1/_2$-in. (outside diameter) silicon-carbide protection tube. This experimental value should hold within close limits for varying wall thicknesses and for varying sizes of elements if the ratio of graphite to silicon carbide remains the same. The ratio for the composite structure of this terminal is 0.733.

From the fundamental equation for heat flow,

$$Q = \frac{K}{S} A(t_1 - t_2),$$

an experimental value of K may be obtained (all other values are known).

Q = quantity of heat transferred = 3981 B.t.u./hr.
S = length of path of flow = wall thickness = 15 in.
A = area (sq. ft.) normal to path of flow = 0.1104 sq. ft.
$t_1 = T_3$ = temp. of terminal at inner face of wall = 2372°F.
$t_2 = T_5$ = temp. of terminal at outer face of wall = 752°F.

$$\text{Thus } K = \frac{QS}{A(T_3 - T_5)} = \frac{3981 \times 15}{0.1104 \times (2372 - 752)} =$$

334 B.t.u./sq. ft./hr./in./°F.

In ascertaining the terminal losses for the pilot kiln, it was necessary to determine the actual bar temperature, T_1, inside the protection tube (Fig. 28) and to calculate the terminal loss by using the conductivity value, K, obtained. Heat emitted by the element will flow through the terminals to be dissipated to the outside atmosphere or will be transferred through the protection tube into the furnace. Equations may be obtained and solved simultaneously for the bar temperature and for the terminal loss from the fundamental equations for heat flow and for heat transfer by radiation.

$$\text{Heat flow} = Q = \frac{K}{S} A(t_1 - t_2). \qquad (1)$$

Heat transfer by radiation =

$$Q = 0.172 \times 10^{-8} A_1(T_o^4 - T_a^4) \frac{1}{\frac{1}{P_1} + \frac{A_1}{A_2}\left(\frac{1}{P_2} - 1\right)}. \qquad (2)$$

Where A_1 = area of emitting surface (sq. ft.).
A_2 = area of receiving surface (sq. ft.).
T_o = temp. of emitting surface (°Abs.).
T_a = temp. of receiving surface (°Abs.).
P_1 = emissivity of emitting surface.
P_2 = emissivity of receiving surface.

Let Q = av. input/element = 8.5 kw. = 29,000 B.t.u.
Q_1 = heat transfer into furnace.
Q_2 = heat flow through one terminal.
T_1 = bar temp.
T_2 = temp. of inner surface of tube.
T_3 = temp. of outer surface of tube.
T_4 = kiln temp. = 2372°F = 2832°Abs.
T_5 = terminal temp. at outer face of wall = 752°F = 1212°Abs.
A_1 = emitting surface of bar = 0.88 sq. ft.
A_2 = area inside of tube = 2.03 sq. ft.
A_3 = area outside of tube = 3.04 sq. ft.
A_4 = area normal to flow of heat through terminals = 0.1104 sq. ft.
S = path of heat flow through terminal = 19 in.
S_1 = path of heat flow through tube = 0.75 in.
K = experimental conductivity factor = 334 B.t.u./sq. ft./hr./in./°F.
K_1 = conductivity factor for silicon carbide = 108 B.t.u./sq. ft./hr./in./°F.
$P_1 = P_2$ = emissivities of graphitized carbon and silicon carbide = 0.95 (assumed).

The following equations may now be developed:

$$\text{Total heat input} = Q = Q_1 + 2Q_2 = 29{,}000. \qquad (3)$$

From equation (2), heat transfer by radiation, the heat transferred from the bar to the inside of the protection tube is

$$Q_1 = 0.172 \times 10^{-8} A_1(T_1^4 - T_2^4) \frac{1}{\frac{1}{P_1} + \frac{A_1}{A_2}\left(\frac{1}{P_2} - 1\right)}.$$

$$Q_1 = 0.172 \times 10^{-8} \times 0.88\,(T_1^4 - T_2^4) \times 0.93. \qquad (4)$$

The same amount of heat flows through the protection tube (from equation (1)),

$$Q_1 = \frac{K_1}{S_1}\left(\frac{A_2 + A_3}{2}\right)(T_2 - T_3).$$

$$Q_1 = 365.0\,(T_2 - T_3). \qquad (5)$$

The same amount is emitted from the outer surface of the tube to the furnace (from equation (2)),

$$Q_1 = 0.172 \times 10^{-8} P_3 A_3 (T_3^4 - T_4^4).$$
$$Q_1 = 49.67 \times 10^{-10} T_3^4 - 319{,}500. \qquad (6)$$

The remainder of the heat input flows through the terminals (from equation (1)),

$$Q_2 = \frac{K}{S} A_4(T_1 - T_5).$$

$$Q_2 = 1.94\,T_1 - 2351. \qquad (7)$$

The simultaneous solution of equations (3) through (7) gives a value of 3080°F Abs. for the bar temperature (T_1). The B.t.u. loss per terminal per hour is Q_2. From equation (7),

$Q_2 = (1.94 \times 3080) - 2351 = 3624$ B.t.u./hr.

Total loss for 28 terminals =

$$\frac{3624 \times 28}{3412} = 29.74 \text{ kw.-hr./hr.}$$

A large number of fireclay shapes were used to construct the kiln walls to provide openings for atmosphere sampling tubes, thermocouples, gas inlets, pressure points, etc., because the kiln was built primarily for experimental purposes, and practically nothing was known about the behavior of an electric kiln under various operating conditions. It is impossible, therefore, to calculate the theoretical heat transfer through the kiln walls, nor can definite conclusions be made as to the amount of heat lost due to air leaks. The quantity of air put into the kiln was measured, but the temperature at which this air escaped was unknown. It was noted, however, that no difference in power input could be detected when the kiln was operated under natural pressure compared to a positive pressure of 0.020 to 0.025 in. water-gage pressure. This indicates that the air-loss in a kiln with a fairly tight steel shell, even with the nonuniform wall construction, is small, and might be included with the radiation and convection losses from the walls, which in this case is the difference between the quantity of heat put into the kiln and those losses which have been accounted for.

The heat balance on the pilot kiln may now be given as follows:

Total input to kiln		120.00 kw.
Carried out in load	6.50 kw.	
Loss through terminals	29.74	
Loss through walls and air leakage	83.76	
	120.00 kw.	120.00 kw.

VII, PROBABLE HEAT LOSS AND EFFICIENCY OF A THEORETICAL, COMMERCIAL ELECTRIC KILN

By M. G. Toole and M. S. Nelson

The heat unit as produced from electricity usually costs from two to ten times as much as heat from other types of fuel. This does not mean that the electric heat unit is prohibitive but that greater precautions must be taken to prevent heat loss, *e.g.*, added insulation to the walls of the electric kiln gives a greater saving in dollars than insulation in kilns using other types of fuel. This fact was kept in mind when the theoretical kiln was designed. It is not to be understood, however, that the sizes, shapes, and thicknesses of the parts of construction in this theoretical kiln are ideal. A wall thickness was chosen to show how this heat loss may be minimized without considering the cost of materials.

From tests conducted on the pilot kiln, it is believed that if heat is applied above and below the load, an even heat distribution can be maintained in a twin-tunnel kiln with a tunnel cross section of 2 by 2 ft. each. Where conditions demand, the height could be extended to 3 ft. and the width determined by the length of the heating element that can be obtained. For the following calculations, a 2- by 2-ft. twin-tunnel, walking-beam kiln, with 30-in. walls in the hot zone and 21-in. walls near the ends, is considered. The over-all length of 150 ft. is believed to be the most practicable for a walking-beam kiln. The ceramic load, fired to a temperature of 2372°F (1300°C), is to pass through the kiln in 24 hours. The temperature gradient between the middle of the kiln and the ends for a 24-hour schedule is considered to be the same as that in the 55-ft. pilot kiln on a 24-hour schedule.

As noted in Part VI, the heat necessary to maintain a constant temperature on a closely constructed electric kiln may be divided into (1) heat used in endothermic reaction of firing ware, (2) heat lost in slabs, supports, and load leaving kiln, (3) heat lost from terminals of heating elements, and (4) heat transfer through walls of kiln.

(1) *Heat Used in Endothermic Reaction of Firing Ware:* When firing ceramic ware, a change of state is known to take place within the body. This change requires a certain amount of heat which does work and is not given up when the ware is cooled. The specific heat for green ceramic ware, fired to 2372°F, is 0.40, but the fired ware gives up only 0.24 B.t.u. per lb. per °F when cooling, the difference being due to the heat of endothermic reaction. The kiln, operating on a 24-hour schedule and with a load of 25 lb. per cu. ft., delivers 1250 lb. of ware per hour. The ambient temperature is 100°F; therefore, the heat of endothermic reaction is

$$Q_E = \frac{(0.40 - 0.24)\,(2372 - 100) \times 1250}{3412} = 133.0 \text{ kw.-hr./hr.}$$

(2) *Heat Lost in Slabs, Supports, and Load Leaving Kiln:* Because the kiln is 150 ft. long and operates on a 24-hour schedule, the slab train and load will move at the rate of 150/24 = 6.25 ft. per hr. The load, 25 lb. per cu. ft. in each tunnel, will give the following total load of ware:

$$(6.25 \times 25 \times 2 \times 2) \times 2 = 1250 \text{ lb./hr.}$$

The corresponding weight of the slabs (weighing 46 lb. per linear ft.) is

$$(6.25 \times 46) \times 2 = 575 \text{ lb. slabs/hr.}$$

Assume twice this weight, 1150 lb. per hour, to allow for extra ware supports.

If the load enters the kiln at a temperature of 100°F, leaves at 660°F, and has a specific heat of 0.24 for fired ware and 0.18 for clay-bonded silicon-carbide slabs, the heat carried out will be

$$\text{Ware} = Q_W = 1250 \times 0.24\,(660 - 100) = 168{,}000 \text{ B.t.u./hr.}$$

$$\text{or } \frac{168{,}000}{3412} = 49.2 \text{ kw.-hr./hr.}$$

$$\text{Slabs and supports} = Q_S = 1150 \times 0.18\,(660 - 100) = 115{,}920 \text{ B.t.u./hr.}$$

$$\text{or } \frac{115{,}920}{3412} = 34.0 \text{ kw.-hr./hr.}$$

Total loss in load = 49.2 + 34.0 = 83.2 kw.-hr./hr.

(3) *Heat Loss through Terminals of Heating Elements:* As previously calculated in Part VI, the thermal-conductivity factor for a terminal with a graphite-to-silicon carbide ratio of 0.733 is 334 B.t.u. per sq. ft. per hr. per °F per in.

To use a graphite heating element, a silicon-carbide tube, 11 ft. 2 in. long by 5 in. (inside diameter) by 7½ in. (outside diameter) would be necessary. The graphite terminal would be 32 in. long by (approximately) 5 in. (diameter). The heating-element rod would be about 2 in. (diameter) by 62 in. long.

To determine the heat flow through the terminal, it is necessary to substitute the following values in equations (1) and (2) of Part VI:

Q = B.t.u. rating of heating element = 15.0 kw. = 51,200 B.t.u./hr.
T_4 = inside kiln temp. = 2372°F.
T_3 = outside temp. of terminal = 527°F (assumed).
A_1 = dispersing area of rod = 2.71 sq. ft.
A_2 = inside area of tube = 6.77 sq. ft.
A_3 = outside area of tube = 10.12 sq. ft.
A_4 = area normal to flow of heat through terminals = 0.3068 sq. ft.
S = path of heat flow through terminal = 32 in.
S_1 = thickness of tube wall = 1.25 in.
K = experimental conductivity factor = 334 B.t.u./sq. ft./hr./°F/in.
K_1 = thermal-conductivity factor of tube = 108 B.t.u./sq. ft./hr./°F/in.
$P_1 = P_2$ = emissivity factor (assumed) = 0.95.

Substituting these values gives the following equations:

$$Q_2 = 25{,}600 - \frac{Q_1}{2} \qquad (8)$$

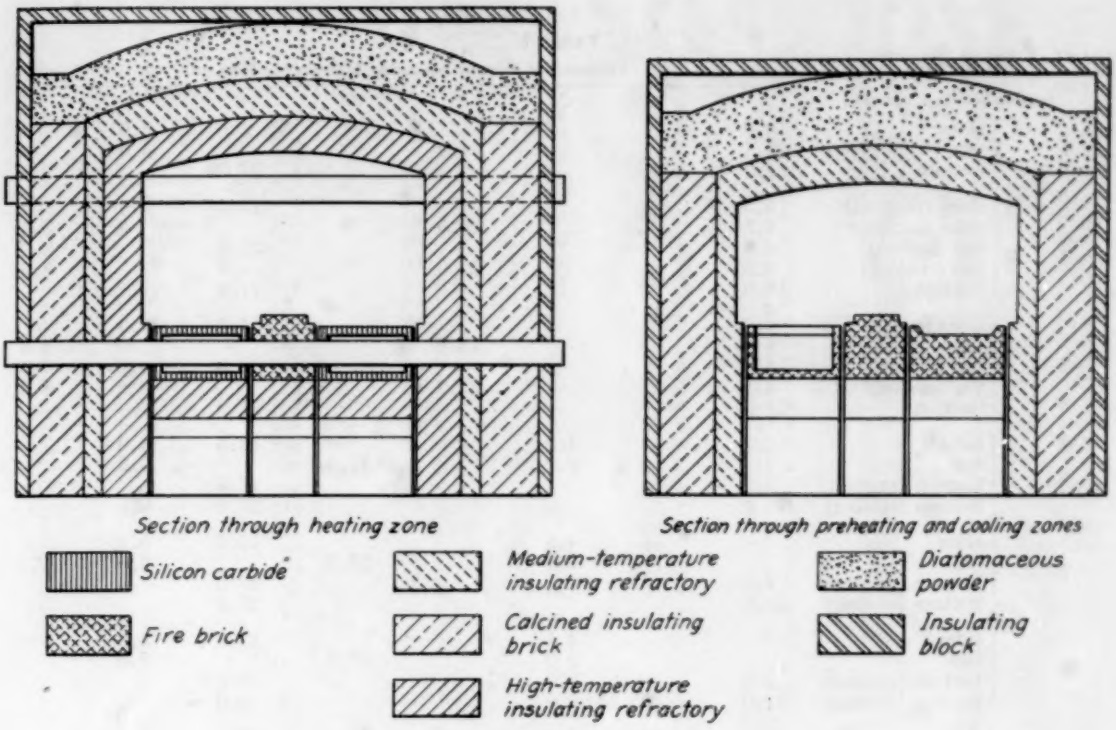

FIG. 29.

$$Q_1 = 0.4341\ (T_1^4 - T_2^4) \times 10^{-8}. \quad (9)$$
$$Q_1 = 729.6\ (T_2 - T_3). \quad (10)$$
$$Q_1 = 1.654\ (T_3^4 - T_4^4) \times 10^{-8}. \quad (11)$$
$$Q_2 = 3.202\ T_1 - 3161. \quad (12)$$

The simultaneous solution of equations (8) through (12) gives a value of 2995°F Abs. for T_1.

Substituting this value for T_1 in equation (12),

$$Q_2 = 3.202 \times 2995 - 3161.$$
$$Q_2 = 6429 \text{ B.t.u. loss/hr./terminal,}$$
$$\text{or } \frac{6429}{3412} = 1.884 \text{ kw. loss/terminal,}$$
$$\text{or } 2 \times 1.884 = 3.77 \text{ kw. loss/heating element.}$$

If 30 elements are required to heat the kiln, the terminal loss will be 113.1 kw.-hr. per hr.

(4) *Heat Transfer through Walls of Kiln:* Figure 29 shows cross-section views of the hot zone and preheating and cooling zones. For purposes of calculation, the kiln is divided into 30 sections of 5 ft. each (Fig. 30). A 24-hour schedule is considered both for the 150-ft. and the 55-ft. kiln, and it is believed that the temperature distributions between the hot zones and the ends of the kilns would be approximately the same. The temperature distribution of the present kiln, consequently, was applied to the 150-ft. kiln (Fig. 31).

FIG. 30.

The B.t.u. loss per square foot for various wall compositions and thicknesses (Table I) was calculated according to the Heilman method[36] and is given in Table II.

An example of the heat loss through the side walls is given for section No. 14. From Fig. 31, the average hot-face temperature of section No. 14 (7.5 ft. from center of kiln) is 2327°F. Assume interface temperatures and shell temperature (Fig. 32).

[36] R. H. Heilman, "Calculation of Heat Losses through Furnace Walls," *Amer. Refrac. Inst. Tech. Bull.*, No. 47, 8 pp. (February, 1934); *Ceram. Abs.*, **13** [6] 153 (1934).

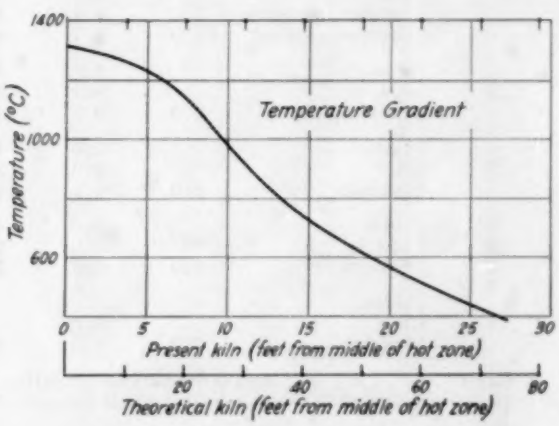

FIG. 31.

TABLE I

Thickness of Various Insulating Materials in Kiln (in.)

Section No. and Location		*A*	*B*	*C*	*X*	*D*	*E*	*F*	*G*
1	sides	18.0						3.0	
	top	22.5			4.0			3.0	
	bottom	11.0					27.0		
2	sides (preheat)	4.5					13.5	3.0	
	sides (cooling)	4.5			13.5				3.0
	top (preheat)	4.5					22.0		3.0
	top (cooling)	4.5			22.0				3.0
	bottom	11.0					27.0		
3	sides (preheat)	4.5					13.5	3.0	
	sides (cooling)	4.5			13.5				3.0
	top (preheat)	4.5					22.0		3.0
	top (cooling)	4.5			22.0				3.0
	bottom	11.0					27.0		
4	sides			4.5			13.5	3.0	
	top			9.0		17.5		3.0	
	bottom (preheat)	2.0					27.0		
	bottom (cooling)	11.0					27.0		
5	sides			4.5			13.5	3.0	
	top			9.0		17.5		3.0	
	bottom (preheat)	2.0					27.0		
	bottom (cooling)	11.0					27.0		
6	sides			4.5			13.5	3.0	
	top			9.0		17.5		3.0	
	bottom (preheat)	2.0		9.0			18.0		
	bottom (cooling)	11.0		9.0			18.0		
7	sides			4.5			13.5	3.0	
	top			9.0		17.5		3.0	
	bottom (preheat)	2.0		9.0			18.0		
	bottom (cooling)	11.0		9.0			18.0		
8	sides			4.5			13.5	3.0	
	top			9.0		17.5		3.0	
	bottom (preheat)	2.0		9.0			18.0		
	bottom (cooling)	11.0		9.0			18.0		
9	sides			4.5		13.5			3.0
	top		9.0			17.5			3.0
	bottom (preheat)	2.0		9.0			18.0		
	bottom (cooling)	11.0		9.0			18.0		
10	sides		4.5	4.5			9.0		3.0
	top		9.0	4.5		13.0			3.0
	bottom (preheat)	2.0	9.0	4.5			13.5		
	bottom (cooling)	11.0	9.0	4.5			13.5		
11	sides		4.5	4.5			9.0		3.0
	top		9.0	4.5		13.0			3.0
	bottom (preheat)	2.0	9.0	4.5			13.5		
	bottom (cooling)	11.0	9.0	4.5			13.5		
12	sides		9.0	4.5			13.5		3.0
	top		9.0	9.0		13.0			3.0
	bottom	2.0	9.0	4.5			13.5		
13	sides		9.0	4.5			13.5		3.0
	top		9.0	9.0		13.0			3.0
	bottom	2.0	9.0	4.5			13.5		
14	sides		9.0	4.5			13.5		3.0
	top		9.0	9.0		13.0			3.0
	bottom	2.0	9.0	4.5			13.5		
15	sides		9.0	4.5			13.5		3.0
	top		9.0	9.0		13.0			3.0
	bottom	2.0	9.0	4.5			13.5		

Materials *A*, *B*, *C*, *D*, *E*, *F*, and *G* are various insulating refractories chosen to meet highest commercial specifications; *X* is air space provided in one side wall and half the roof of first three sections to aid in cooling out-going ware.

TABLE II

Section No.	Location	Shell temp. (°F)	B.t.u./ sq. ft./hr.	L	D	Area (sq. ft.)	Total B.t.u./hr./ section	No. of sections	Total B.t.u./hr. loss
				Sides					
1	Common	148.0	72.8	18.80	91.4	38.0	2760	4	11040
2	Preheat	128.0	42.5	14.80	78.5	33.7	1430	2	2860
2	Cooling	168.0	106.5	19.30	93.0	38.7	4120	2	8240
3	Preheat	133.0	47.6	14.80	78.5	32.7	1560	2	3120
3	Cooling	176.0	120.0	19.30	93.0	38.7	4650	2	9300
4	Preheat	132.0	48.5	13.71	78.2	32.6	1580	2	3160
4	Cooling	132.0	48.5	13.71	75.1	31.3	1520	2	3040
5	Preheat	136.0	53.7	13.82	78.5	32.7	1750	2	3500
5	Cooling	136.0	53.7	13.82	75.2	31.3	1680	2	3360
6	Preheat	140.0	60.1	13.77	78.3	32.6	1960	2	3920
6	Cooling	140.0	60.1	13.77	75.2	31.4	1890	2	3780
7	Preheat	144.0	67.1	13.79	78.3	32.6	2190	2	4380
7	Cooling	144.0	67.1	13.79	75.2	31.4	2110	2	4220
8	Preheat	150.0	75.3	13.83	78.5	32.7	2460	2	4920
8	Cooling	150.0	75.3	13.83	75.4	31.4	2360	2	4720
9	Preheat	156.0	85.5	14.30	79.8	33.2	2840	2	5680
9	Cooling	156.0	85.5	14.30	76.9	32.0	2735	2	5470
10	Preheat	168.0	107.1	15.30	82.6	34.4	3690	2	7380
10	Cooling	168.0	107.1	15.30	80.3	33.4	3580	2	7160
11	Preheat	178.0	126.2	15.35	82.1	34.4	4350	2	8700
11	Cooling	178.0	126.2	15.35	80.4	33.4	4220	2	8440
12	Common	168.0	106.5	21.28	89.7	37.4	3990	4	15960
13	"	172.0	113.5	21.42	90.0	37.5	4260	4	17040
14	"	174.0	117.5	21.44	90.1	37.5	4400	4	17600
15	"	176.0	120.8	21.53	90.1	37.5	4520	4	18080
Doors	"	199.0	163.8			14.7	2400	2	4800
				Top					
1	Common	143.0	67.7	27.1	106.5	44.5	3020	2	6040
2	Preheat	117.5	27.2	18.5	47.1	19.7	535	2	1070
2	Cooling	165.0	105.0	27.8	53.7	22.4	2360	2	4720
3	Preheat	125.0	34.8	19.1	47.5	19.9	695	2	1390
3	Cooling	174.0	122.4	27.8	53.8	22.4	2740	2	5480
4	Common	122.0	33.5	18.4	94.1	39.2	1310	2	2620
5	"	124.0	38.4	18.7	94.7	39.5	1520	2	3040
6	"	126.0	42.1	18.7	94.7	39.5	1660	2	3320
7	"	130.0	47.1	18.7	94.7	39.5	1860	2	3720
8	"	135.0	55.3	18.9	94.8	39.5	2180	2	4360
9	"	142.0	66.0	19.7	96.0	40.0	2640	2	5280
10	"	152.0	82.8	20.9	97.7	40.7	3320	2	6640
11	"	160.0	95.7	21.0	97.8	40.7	3900	2	7800
12	"	162.0	99.4	24.4	111.1	46.5	4620	2	9240
13	"	165.0	105.0	24.5	111.2	46.5	4880	2	9760
14	"	166.0	109.0	24.5	111.2	46.5	5070	2	10140
15	"	170.0	113.7	24.5	111.2	46.5	5300	2	10600
				Bottom					
1	Common	129.0	27.8	23.4	93.8	39.1	1090	2	2180
2	"	133.0	31.6	23.5	93.9	39.1	1230	2	2460
3	"	137.0	35.7	23.7	94.2	39.2	1400	2	2800
4	Preheat	142.0	42.3	15.4	37.1	15.5	670	2	1340
4	Cooling	140.0	39.8	23.5	55.0	22.9	910	2	1820
5	Preheat	145.0	46.8	15.3	37.1	15.5	725	2	1450
5	Cooling	142.0	43.5	23.5	55.0	22.9	995	2	1990
6	Preheat	153.0	56.8	16.9	38.2	15.9	905	2	1810
6	Cooling	150.0	53.2	25.0	55.8	23.2	1230	2	2460
7	Preheat	157.0	63.6	17.0	38.3	16.0	1020	2	2040
7	Cooling	155.0	59.4	25.0	55.8	23.2	1370	2	2740
8	Preheat	165.0	72.7	17.1	38.4	16.0	1160	2	2320
8	Cooling	160.0	68.0	25.3	55.9	23.2	1570	2	3140
9	Preheat	173.0	83.5	17.2	38.4	16.0	1340	2	2680
9	Cooling	168.0	78.2	25.4	56.0	23.3	1820	2	3640
10	Preheat	188.0	106.3	18.8	39.6	16.5	1760	2	3520
10	Cooling	182.0	97.3	24.5	55.5	22.9	2220	2	4440
11	Preheat	200.0	124.0	18.8	39.6	16.5	2050	2	4100
11	Cooling	194.0	114.0	24.5	55.5	22.9	2610	2	5220
12	Common	226.0	168.0	19.4	108.0	45.0	7570	2	15140
13	"	226.0	168.0	19.4	108.0	45.0	7570	2	15140
14	"	226.0	168.0	19.4	108.0	45.0	7570	2	15140
15	"	226.0	168.0	19.4	108.0	45.0	7570	2	15140

Total B.t.u./hr. passing through kiln walls = 397,800

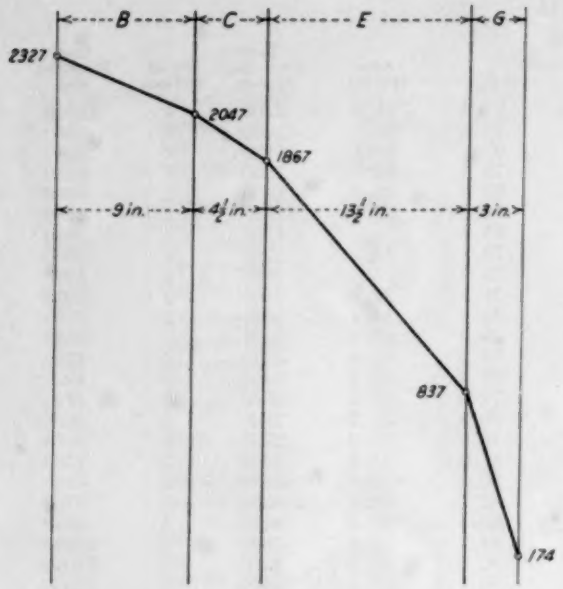

FIG. 32.

The average temperatures for each material are as follows:

$$B = \frac{2327 + 2047}{2} = 2187.$$

$$C = \frac{2047 + 1867}{2} = 1957.$$

$$E = \frac{1867 + 837}{2} = 1352.$$

$$G = \frac{837 + 174}{2} = 505.$$

From Fig. 33, the thermal conductivities for these average temperatures are as follows:

Material	K (conductivity)	R (resistance)
B	3.75	2.40
C	2.82	1.60
E	1.54	8.77
G	0.54	5.55

Where $R = \frac{L}{K} = \frac{\text{thickness of insulation (in.)}}{\text{thermal conductivity}}$.

The equation for heat flow, Q, through the wall is

$$Q = \frac{t_i - t_o}{\frac{L_1}{K_1} + \frac{L_2}{K_2} + \frac{L_3}{K_3} + \frac{L_4}{K_4}} = \text{B.t.u./sq. ft./hr.}$$

Where t_i = inner face temp.
t_o = shell temp.
L_2, L_3, L_2, L_4 = thickness of insulation (in.)
K_1, K_2, K_3, K_4 = corresponding thermal conductivities.

Then $Q = \frac{2327 - 174}{2.40 + 1.60 + 8.77 + 5.55} = 117.5$ B.t.u./sq. ft./hr.

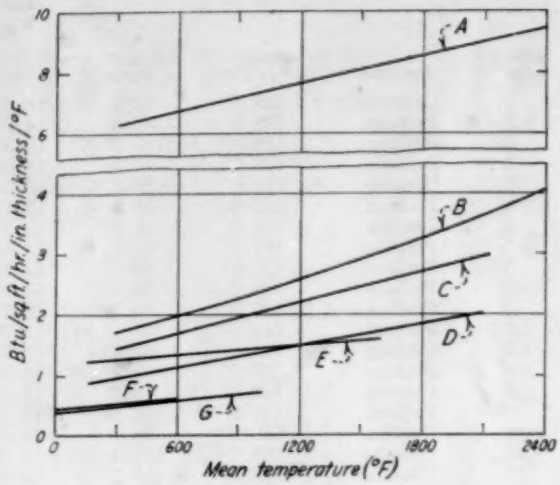

FIG. 33.

From the curve for total losses from side walls (Fig. 34), a loss of 117.5 B.t.u. per sq. ft. per hr. corresponds to a shell temperature of 174°F, thus showing the assumed shell temperature to be correct. As a check to see whether or not the assumed intermediate face temperatures are correct, the heat flow should be multiplied by each R, because the temperature drop through each material equals the actual resistance times the heat flow.

$$\left.\begin{array}{l} 117.5 \times 2.40 = 282° \\ 117.5 \times 1.60 = 188° \\ 117.5 \times 8.77 = 1031° \\ 117.5 \times 5.55 = 652° \end{array}\right\} \text{drop through} \left\{\begin{array}{l} B \\ C \\ E \\ G \end{array}\right.$$

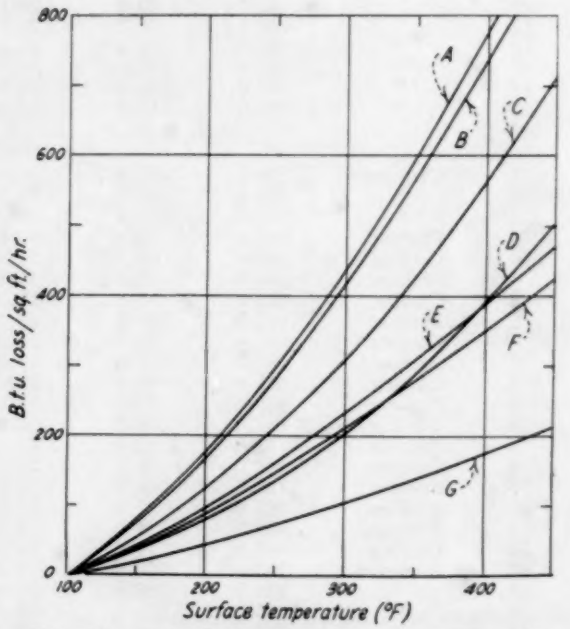

FIG. 34.—*A* (top), *B* (side wall), and *C* (bottom), total loss; *D*, radiation loss; *E* (top), *F* (side wall), and *G* (bottom), convection loss.

This shows that the assumed temperatures were close enough to give correct average values for thermal conductivities from the curves of Fig. 32.

Although Heilman's method is accurate for heat flow normal to a wall, it does not take into account the effect of corners, which is important in furnaces with walls more than a few inches thick. In such walls, the amount of heat flow (therefore the heat loss by radiation and convection) will depend on the thickness and thermal conductivities of the various materials used. If a poor insulator of considerable thickness is placed on the inside of the furnace wall, obviously the interface temperatures between it and the next material will

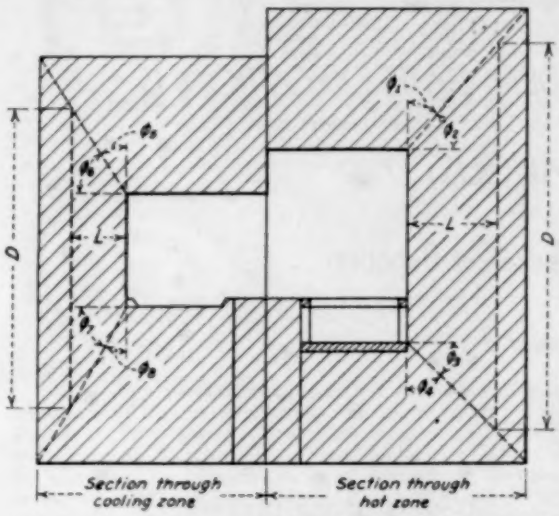

FIG. 35.

be only slightly lower than the kiln temperature and a large area will be at a high temperature. This, in turn, will tend to heat up a larger area as the outside of the wall is approached, owing to the increased periphery, which causes a high heat loss. Conversely, if the poor insulator placed on the inside of the furnace wall is thin, the interface temperature does not change greatly, but a much smaller area of the next material will be at the high temperature with a corresponding decrease in shell loss. Thus, the total heat loss through a wall depends on the resistances of its various materials, and they must be taken into consideration in determining this loss.

The equivalent heat-dissipating area is taken at the midpoint of thermal resistance of the wall. From the example, the total resistance is

$$2.40 + 1.60 + 8.77 + 5.55 = 18.32.$$

$$\frac{18.32}{2} = 9.16 \text{ half-resistance of wall.}$$

The distance, L, to the midpoint of thermal resistance is 21.44 in. from the inside of the kiln, and at this point (Fig. 35) the vertical dimension, D, is 90.1 in. For a 5-ft. section, the equivalent area is

$$A = \frac{90.1 \times 60}{144} = 37.5 \text{ sq. ft.}$$

The total B.t.u. loss for that section is

$$37.5 \times 117.5 = 4400 \text{ B.t.u./hr.}$$

Similar data on heat losses for sides, top, and bottom for all sections were determined, and the results are tabulated in Table II.

The B.t.u. loss for a given temperature is less from the bottom and more from the top than for the sides; Langmuir[37] has found that a horizontal surface facing downward is subject to 50% normal convection loss only, and one facing upward is subject to 110% normal convection loss. An emissivity factor of 0.50 for the radiation loss was used,[37] allowing for an aluminum bronze coating on outer surface of kiln shell.

From Table II, the total loss through the walls of the kiln is 397,800 B.t.u. per hr. (or 397,800/3412 = 116.5 kw.-hr. per hr.).

From the various calculated losses, the total power necessary to operate the kiln may be determined.

(1) kw. for endothermic reaction = 133.0.
(2) kw. equivalent carried out in load and slabs = 83.2.
(3) " " passing out through terminals = 113.1.
(4) " " passing through kiln walls = 116.5.
Total kw. power necessary to fire kiln = 445.8

This gives 1250/445.8 = 2.8 lb. net per kw.-hr.

As noted in Part VI, air leakage is considered to be negligible in well-constructed kilns.

The efficiency of this kiln could be increased, either by operating on a shorter schedule or by increasing the load per square foot of loading space. This would increase the pay load being fired with only a slight increase in power consumption. Inasmuch as the heating elements give a very soft heat at their low wattage dispersion, making the heat differential between the element and the kiln walls very small, a much faster schedule could be followed on many types of ware.

NOTE FROM HEWITT WILSON, JUNE 7, 1939*

The analysis of clay (A) was made on a sample received at the laboratory December 3, 1936, and that of clay (B) on a sample received January 28, 1938. Because the analyses indicated differences that were not found in the physical tests made during the last half of 1938 and the first half of 1939, a new analysis of clay (A), washed during 1939, was determined by J. E. Boyd, chief chemist of the Tennessee Mineral Products Company, who reported as follows: SiO_2 50.80, Al_2O_3 35.55, Fe_2O_3 0.45, CaO 0.10, MgO no data, K_2O 0.98, Na_2O 0.15, and loss 12.00%, a total of 100.03%.

The calculated mineral analysis includes kaolinite 86.35, orthoclase 5.79, albite 1.28, anorthite 0.49, and quartz 5.77%.

Washing tests of clay (B) show that the chief mineral impurity is mica. The mineral analysis calculated on the muscovite basis indicates 90.5% kaolinite, 4.9% muscovite, 1.83% anorthite, and 0.85% albite. There is no necessity in this case to consider a free alumina component.

[37] Irving Langmuir, "Convection and Radiation of Heat," *Trans. Amer. Electrochem. Soc. Reprint*, pp. 299–332 (April, 1913).

* Dr. Wilson is Supervising Engineer, Electrotechnical Lab., Bureau of Mines, Norris, Tenn.

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On The Island

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Court of the Moon, Golden Gate International Exposition

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Journal Reference: The journal name appears in italics, followed by the volume (bold-faced), issue number (in brackets), page numbers, and year (in parentheses).

July, 1939
18—7

Abrasives

Comparative properties of metallic surfaces polished mechanically and electrolytically. P. A. Jacquet. Presented at First International Electrodeposition Conference, London, March, 1937; *Jour. Iron & Steel Inst.*, **136** [2] 42A (1937).—Metallic surfaces polished by the usual procedure, which involves mechanical treatment, and by the electrolytic process have quite different structures. Mechanically polished surfaces show no crystalline properties; apart from the superficial, probably amorphous, layer there exists a more or less thick zone of microcrystals having no resemblance to the crystals of the metal. The properties of such a surface are bound up with this special structure and are not specific to the metal. Electrolytic polishing (a type of etching) allows the properties of the crystal faces to be studied.

Experiments with boron carbide in different applications. W. Dawihl and K. Schröter. *Werkstattstechnik*, **31** [9] 201–204 (1937).—Boron carbide ranges in hardness between silicon carbide and diamond. As a grinding powder for diamond dies, it is 3 times as good as silicon carbide but can not compete with diamond powder. As grinding powder for metal carbide dies it is highly superior (30 times) to silicon carbide and has an efficiency 65% that of diamond powder. Its use in grinding wheels is unsuccessful so far, as no suitable bond has yet been found. For cutting tools, wire dies, and wheel dressers, boron carbide is inferior to the carbides which are regularly used; for sandblast nozzles it is equivalent to the best metal alloys now on the market. J.M.N.

Grinding metal wires. M. Bonzel. *Métaux & Corrosion*, **13** [152] 72–76 (1938).—An arrangement of a centerless grinding apparatus is described in which small rods and wires are ground and polished between a large grinding wheel and a smaller wheel with a hyperbolically shaped surface with the shaft arranged obliquely with respect to the shaft of the working wheel; this assures the advance of the wire. Fatigue limit and surface properties are improved by this treatment. M.H.

Grinding sintered carbide-tipped tools. Malcolm F. Judkins. *Mech. Eng.*, **59** [12] 897–901 (1937).—J. discusses the requirements of rough grinding, the classes of finish grinding, and the uses of the cutter grinder. Data are presented on the wide range of machines and wheels available. Illustrated. F.G.H.

Lapping. G. Wolff. *Werkstattstechnik*, **31** [20] 441–45 (1937).—W. deals in detail with the purpose of lapping, the apparatus used, and the complete technique of the process. He recommends the use of a mixture of 7 parts rapeseed oil, 1 part naphtha, and 1 part lapping powder. The lapping powder should be emery (finest grain), chromic oxide, Vienna polishing lime, or polishing rouge. To obtain a bright surface, chromic oxide is best suited, and its use is recommended in the second operation of a two-step process. J.M.N.

BOOK

Workshop Primers: No. 9, Grinding (Werkstattkniffe: No. 9, Schleifen). K. Potyka. Carl Hanser Verlag, Munich, 1938. 63 pp. Price 1.80 M. Reviewed in *Bull. Brit. Non-Ferrous Metals Research Assn.*, No. 119, p. 116 (1939).—P. discusses abrasives and their selection and gives an account of various types of grinding and methods of inspection for mass-production work. General reference is made to materials, both nonferrous and ferrous.

PATENTS

Abrading or polishing machine. Mattison Machine Works. Brit. 502,898, April 13, 1939 (Jan. 15, 1937).

Abrading roll. E. E. Price (G. H. Tennant Co.). U. S. 2,158,014, May 9, 1939 (July 1, 1935; May 24, 1937).

Abrasive. W. E. Catlin (E. I. du Pont de Nemours & Co., Inc.). U. S. 2,154,436, April 18, 1939 (April 13, 1937).—An abrasive composition comprises finely divided abrasive material intimately mixed and bonded with synthetic linear condensation polyamide.

Abrasive article. E. I. du Pont de Nemours & Co., Inc. Brit. 503,542, April 26, 1939 (Oct. 8, 1936).

Centerless grinding machine. R. H. Cramer (General Motors Corp.). U. S. 2,156,562, May 2, 1939 (May 23, 1936).

Cylinder grinding device. Carborundum Co. Brit. 503,145, April 13, 1939 (Oct. 2, 1936).

Device for axial to-and-fro movement of grinding shafts

by means of a reeling disk. KURT SANDT. Ger. 669,471, Dec. 1, 1938 (Sept. 19, 1936); XII/67*a*. 32.02.—The supporting members for the disk are located on a common revolving part which holds them in a stationary position with regard to the disk by the action of springs. D.A.B.

Device for determining grinding position on workpieces with machines for grinding profiles of bars on revolving workpieces of all sorts. R. STOCK & CO. SPIRALBOHRER-, WERKZEUG- UND MASCHINENFABRIK A.-G. Ger. 670,341, Dec. 22, 1938 (April 3, 1936); XII/67*a*. 1. D.A.B.

Device for inserting working material into machines for grinding, polishing, and finishing razor blades. RICHARD RÖLL. Ger. 668,615, Nov. 17, 1938 (July 11, 1936); XII/67*a*. 7. D.A.B.

Dressing the flange of cast grinding wheels with a large grinding surface by means of a chisel-shaped dressing tool. HERBERT LINDNER. Ger. 669,650, Dec. 8, 1938 (Nov. 25, 1935); XII/67*a*. 26.—A diamond tool with a wide cutting edge is employed. D.A.B.

Flexible grinder. LEOPOLD CHURGIN. U. S. 2,155,037, April 18, 1939 (Nov. 17, 1937).

Grinding cylindrical workpieces. CONRAD THYSSEN (Schumag Schumacher Metallwerke A.-G.). U. S. 2,156,485, May 2, 1939 (Jan. 3, 1939).

Grinding machine. A. P. BURNS (Heald Machine Co.). U. S. 2,156,970, May 2, 1939 (July 3, 1937).

Grinding machine. A. E. HAMILTON AND L. M. STEMPEL. U. S. 2,156,453, May 2, 1939 (July 6, 1936; renewed Aug. 27, 1938).—A grinding apparatus comprises a rotatable grinding wheel, work holders, a carrier movably supporting the holders and rotatable to bring the work holders successively into operative position with respect to the grinding wheel, means for rotating the carrier intermittently, means operative in predetermined relation to movement of the carrier for shifting each work holder longitudinally of the carrier while such holder is in grinding position and while the carrier is stationary, and means operated by the movement of the work holder for controlling the intermittent movement of the carrier.

Grinding of threads. HERMANN HIPPLE (Franz Förg). Ger. 669,530, Dec. 8, 1938 (Oct. 5, 1936); XII/67*a*. 3.—Application is made of a ring-shaped grinding wheel supported on its outer circumference by a holder which is tooled corresponding to the thread form on its inner circumference. D.A.B.

Lapping or abrading tool. W. E. HOKE. U. S. 2,158,-123, May 16, 1939 (July 27, 1937).

Lapping device. BOVAR-SCHULTZ CORP. Brit. 503,124, April 13, 1939 (Jan. 17, 1938).

Machine for making blown glassware. KENT-OWENS MACHINE CO. Brit. 503,921, April 26, 1939 (Nov. 2, 1936).

Making abrasive metal carbides. R. R. RIDGWAY (Norton Co.). U. S. 2,155,682, April 25, 1939 (Nov. 21, 1935; May 14, 1936).

Manufacturing grinding wheels of abrasive material. G. E. VANCE (Safety Grinding Wheel & Machine Co.). U. S. 2,157,779, May 9, 1939 (Jan. 28, 1936).—The method of manufacturing a grinding wheel of abrasive material consists in placing the green abrasive material in a balanced tiltable mold, rotating the mold to determine the heavy and light sides thereof if any exist, removing abrasive material from the heavy portion of the mold to a lighter portion to balance the mold and material, pressing the material in the mold, and thereafter firing the material.

Method and apparatus for grinding toothed wheels. ERNEST HUFF (Wehr Steel Co.). U. S. 2,158,423, May 16, 1939 (Nov. 3, 1937).

Polishing and abrading head. O. P. HILL. U. S. 2,156,179, April 25, 1939 (Feb. 26, 1938).

Producing abrasives. DEUTSCHE CARBORUNDUM-WERKE G. M. B. H. Ger. 668,988, Nov. 24, 1938 (June 24, 1935); IV*c*/39*b*. 5. Addition to Ger. 579,336.—A mixture of abrasive particles and an artificial dispersion of coagulated rubber and vulcanizing agent is almost completely dried without intermediate treatment and then heated to a temperature lying just below the vulcanizing temperature of 105° to 125°C; the mixture is reduced to a loose mass. D.A.B.

Producing artificial whetstones. HEINRICH HOLCH. Ger. 671,038, Jan. 12, 1939 (Aug. 21, 1936); VI/80*b*.11.—Whetstones are produced from a mixture of finely pulverized quartzite and a binding agent that hardens with the addition of water or a binding agent of organic nature; the mixture is cast and subjected before hardening to a pressure of about 2000 to 3500 kg./sq. cm. D.A.B.

Producing boron carbide containing no free carbon and having a boron content exceeding that of B_4C. RAYMOND RONALD RIDGWAY (Norton Co.). Ger. 669,558, Dec. 8, 1938 (June 10, 1937); IV*b*/12*i*. 37.—Boron carbide is produced by the reaction of carbon with boron oxide in an electric resistance furnace when a mixture of boron trioxide and carbon is packed around the resistance; the mixture contains boron in a larger amount than is necessary for the formation of B_4C. There is a gradual continuous heating from the interior of the charge to the exterior under reducing conditions. The charging of the furnace requires less than 0.025 kw./sq. cm. of resistance area and is best between 0.02 and 0.025 kw./sq. cm. D.A.B.

Saw-grinding machine. W. H. THURSTON. U. S. 2,155,809, April 25, 1939 (Jan. 4, 1937).

Sheet-polishing machine. SAUL BLICKMAN. U. S. 2,155,637, April 25, 1939 (May 5, 1937).

Silicon carbide abrasive product and method of manufacture. L. H. MILLIGAN AND R. H. LOMBARD (Norton Co.). U. S. 2,158,034, May 9, 1939 (Jan. 28, 1937).—A vitrifiable ceramic bond comprises a prefired granulated frit combined with material capable of proving the required plasticity and viscosity for bonding silicon carbide grains, the frit constituting at least 50% of the total mass, at least 90% of the total bond containing SiO_2 within the range of 45 to 70%, B_2O_3 within the range of 15 to 40%, and alkali metal oxide within the range of 3 to 10%, and the bond being relatively acidic in nature and capable of maturing at a temperature between 860° and 1040°C without reacting materially with silicon-carbide grains bonded thereby.

Tension flange for preventing the flying off of parts from broken grinding wheels. HANS PAMLER. Ger. 669,003, Nov. 24, 1938 (Aug. 28, 1936); XII/67*c*. 1.—The flying off of broken grinding wheel parts is prevented by the use of a radially operating clamping device. The conical clamping device fits in the wide surface vertical to the axis on the grinding wheel and in the wide conical surfaces against the clamp disk. D.A.B.

Toolhead for grinding machines, etc. W. N. CHITTENDEN. Brit. 503,431, April 19, 1939 (Oct. 20, 1936).

Truing device for grinding wheels. HERMANN HOFER (Zahnradfabrik Friedrichshafen A.-G.). U. S. 2,154,938, April 18, 1939 (March 4, 1937).

Truing mechanism for grinding wheels. JONES & LAMSON MACHINE CO. Brit. 503,989, May 3, 1939 (Jan. 29, 1937).

Work-feeding mechanism for knife-blade grinding or polishing machines, etc. B. WALTERS. Brit. 503,442, April 19, 1939 (Dec. 30, 1937).

Work-rotating devices for grinding machines and other machine tools. F. DECKEL. Brit. 504,245, May 3, 1939 (Aug. 5, 1937).

Workpiece holder for grinding cylindrical surfaces. ALBERT MEYER. Ger. 670,502, Dec. 29, 1938 (Feb. 28, 1934); XII/67*a*. 5.—A workpiece holder for use in grinding a cylindrical surface of adjustable radius, at any inclination or from any direction, on a tool steel by means of a level grinding surface is described. The workpiece holder is located in a fixed ball-and-socket joint, which, together with its casing or frame, is rotatable around an axle lying parallel to the plane of the grinding wheel, and the entire holding apparatus is adjustable on a movable sliding carriage provided with a stop which is vertical to the plane of the grinding wheel so that the swinging axis lies in the plane of the grinding wheel upon fixing of the stop. D.A.B.

Art and Archeology

British Industries Fair. ANON. *Pottery & Glass Record*, **21** [3] 58–68 (1939).—A well-illustrated description is given of a few of the pottery and glass exhibits at the British Industries Fair recently held in London. The illustrations are chiefly of novel designs. One of the most unusual pieces of pottery is a double-walled vase with an air space between the walls and air holes at the base. With this arrangement, the inner pot can be of porous material and well ventilated, while the outer one can be glazed and ornamental. Unusual book ends and ornaments made of glass are shown. A.B.S.

Wilfred Buckley collection of glass. H. GRANVILLE FELL. *Connoisseur*, **98** [419] 110–11 (1936); see "Rare—," *Ceram. Abs.*, **17** [2] 54 (1938). M.E.P.

Ceramic art at exposition of Cleveland Museum of Art, May, 1938. ANON. *Ceram. Age*, **31** [6] 170 (1938).—Illustrated. F.G.H.

Ceramic awards at Paris International Exposition, 1937. ANON. *Ceram. Age*, **30** [6] 169 (1937).—Photographs of some of the ceramic exhibits which received awards at the Paris International Exposition are shown. F.G.H.

Ceramic problem. WILLIAM BOWYER. *Connoisseur*, **98** [421] 227–29 (1936).—Full-page illustration in color of a porcelain mug signed by John Delanauze and dated 1770, probably Bow or Worcester, painted in the workshop of James Giles in Soho, London. The inscription on the base, "This Pint," is believed to have been derived from the German word *pinte* meaning a nearly cylindrical tankard of varying capacity. M.E.P.

Check list of early New England potteries. F. H. NORTON. *Bull. Amer. Ceram. Soc.*, **18** [5] 181–85 (1939).

Chinese porcelains at Cleveland Museum of Art. ANON. *Ceram. Age*, **33** [2] 41 (1939).—Illustrated. F.G.H.

Collectors' piece on De Lancey Street. EMILY KIMBROUGH. *Magazine of Art*, **30** [11] 672–75 (1937).—In the museum-home of A. S. W. Rosenbach, items of interest to ceramic collectors are a pottery jug (Queen Elizabeth's water jug) dated 1594, a chandelier of Waterford glass, mantle pieces of 1780 Bow porcelain, and two tall porcelain jars made by Tucker, a Philadelphia craftsman. Illustrated. M.E.P.

Dinnerware displays at Leipzig Trade Fair, March, 1938. ANON. *Ceram. Age*, **31** [2] 39 (1938).—Illustrated. F.G.H.

Glassmaking in Spain. WERNER GOLDSCHMIDT. *Connoisseur*, **99** [424] 25–29 (1937).—Owing to the fragility of the material and the dearth of historical references, little is known on this subject except the works of the late Gudiol who made a complete study of the pieces extant in public museums and private collections. The oldest examples are of the 4th century B.C.; they are made of glass paste by casting and are decorated with colored glass bands. In the Roman period, glassmaking on the Iberian Peninsula was at its height; in the Romano-Christian era in the 4th and 5th centuries, however, it declined, and only simple greenish bottles full of flaws were made. The invading Visigoths caused further decline but there are a few examples of their work. The Hispano-Moresque period (8th to 11th centuries) must have produced some good quality glass along with the other ceramic products of the time, but few examples remain. The Romanesque period is still more obscure, but from the 14th century documentary evidence supports a better understanding of the craft. Catalonia and Barcelona were important centers in the 15th century. Sixteenth-century Spanish glass is comparable to the best Venetian work. Other important centers at this time were Valencia and Andalucia. Venetian and Arabian influences predominated there. Illustrated. M.E.P.

Heraldic stained glass at Gray's Inn: I. F. SYDNEY EDEN. *Connoisseur*, **98** [419] 16–22 (1936).—E. describes the ancient stained glass used in the elaborate shield patterns of heraldic designs used at Gray's Inn. Most of the colored glass is pot metal and there are some examples of enamel and abraded work. Illustrated. **II.** *Ibid.*, [420] 133–39.—Old glass designs in the east window of the hall are described. Illustrated. For Part IV see *Ceram. Abs.*, **18** [1] 5 (1939). M.E.P.

Historic lamps. ANON. *Electrician*, **122** [3178] 547 (1939).—Additions to the Ediswan collection in Charing Cross Road include specimens of the most famous inventions of lampmakers from 1880 to 1907. Specimens of early glass-blowing efforts are illustrated. H.K.R.

Historic porcelain table services. HELEN COMSTOCK. *Connoisseur*, **98** [419] 45 (1936).—C. reviews an unusual collection of 42 pieces from historic services. A plate made in China for Madame de Pompadour about 1760 is illustrated. M.E.P.

History of the Ceramic Guild of Cincinnati. MARY G. SHEERER. *Bull. Amer. Ceram. Soc.*, **18** [5] 189–90 (1939).

Manufacture of pottery in North Devon. C. W. BRANNAM. *Pottery & Glass Record*, **21** [4] 92 (1939).—B. describes the fine red clay found in North Devon which is used for a large variety of pottery. The carefully selected clays are mixed in suitable proportions, pugged, and shaped by throwing, molding, or pressing. The articles are dried, fired, glazed, and refired. Pottery manufacture in North Devon is at least 1500 years old; it has been a staple trade since the 13th century. The earthenware made in the Bideford and Barnstaple potteries has retained many of its characteristic shapes along with the names given to the various articles and their sizes. The largest size of pitchers was known as "Long Tom"; the next size, as "Thirty Tale"; and others, according to size, as "Gully Mouth," "Dinch Gut," "Sixties," and "Penny Joogs." Pans are still known as "Washing Pans," "Dough Pans," "Cauldron," and "Bawd Pans." The milk pans, still considered unequalled for the quality of the cream they produce, are called "Big Bodleys" and "Little Bodleys." Steins are known as "Busses," "Crocks," "Gallons," "Thirty Tail Pot," "Honey Pot," etc. The method of counting is unique and consists of "Land" dozens and "Sea" dozens, the former comprising 39 and the latter 60 pieces to the trade dozen. A.B.S.

***Pâte-sur-pâte* porcelain.** E. G. ELWYN. *Connoisseur*, **98** [421] 204–208 (1936).—Inspired by slip decoration practiced in China centuries before, this process, used at Sèvres in the middle of the 19th century, evolved ground colors by mixing small amounts of oxides with the paste which in semiliquid form was laid on the porcelain body with a brush in varying thicknesses according to the desired tone. Some of the best examples at Sèvres were done by Marc Louis Emmanuel Solon who later (1870) was employed by the Minton factory, Stoke-on-Trent. The slip on the earliest pieces of both Chinese and Sèvres examples shows a tendency to crack off and peel. The earlier grounds used at Sèvres were grayish green, an effort to reproduce celadon, but Solon later used a dark olive green and then a peacock blue to make more effective contrasts. Illustrated. M.E.P.

Porcelain and earthenware at Leipzig Fall Fair, 1937. HARRISON LEWIS. *Ceram. Age*, **30** [6] 176–77 (1937).—Developments and trends in European porcelain and earthenware are described. F.G.H.

Potter looks at Chinese antiques. WALTER A. WELDON. *Bull. Amer. Ceram. Soc.*, **18** [5] 185–86 (1939).

Pottery: past, present, and future. CHARLES VYSE. *Pottery & Glass Record*, **21** [3] 79–80 (1939).—V., a well-known studio potter, states that in the East pottery is the highest form of art and in China it is esteemed more than sculpture; in England, pottery is not appreciated as it is in Italy and Persia. Raphael made many designs in pottery. The famous potter Hamada is not an artist but his work is finer than any European can produce. V. states that much of the ware exported by Japan today is inferior and that the Chinese have never made any ware so bad in design. In the East there is much mass-production pottery, but the decoration is done by hand, not mechanically, so it has artistic merit. V. describes the

creation of several of his pieces and alludes to his use of wood ashes in the glazes. Most of the pieces are not unique. A.B.S.

Prehistoric pottery found at Atchana. ANON. *Brit. Museum Quart.*, **13**, 21–22 (1939).—When excavating the mound of Atchana (the ancient town of Alalakh) in North Syria, L. Woolley found a palace with a composite structure built at different times. He also discovered clay tablets inscribed in cuneiform with texts in the Akkadian language and naming a king contemporary with Saushsatar, a well-known king of Mitanni in the 15th century B.C., and funerary pottery with white decoration (spirals and birds) on a black ground. **Tall Brak.** *Ibid.*, pp. 22–23.—Excavation of the palace of Naram-Sin, King of Agade at Tall Brak in North Syria, revealed clay tablets of about 2500 B.C., stamp seals in faience and other materials, pottery with white decoration on a black ground similar to that found at Atchana, and many sherds of painted pottery of the Tall Halaf style. See "Pottery—," *Ceram. Abs.*, **17** [10] 323 (1938). A.B.S.

Rakka pottery at Cleveland Museum of Art. HOWARD C. HOLLIS. *Ceram. Age*, **32** [1] 15 (1938).—H. describes the origin and characteristics of Rakka pottery. Illustrated. See "Accessions—," *Ceram. Abs.*, **16** [2] 55 (1937). F.G.H.

Rhages dish. *Connoisseur*, **99** [424] 47 (1937).—Full-page color illustration of a flat dish with upright sides and a narrow grooved rim of sandy white ware with opaque creamy glaze, painted in golden brown luster with ruby reflections. It shows King Khosru discovering Princess Shírín bathing. It is dated A.D. 1210 and is from the Eumorfopoulos collection. M.E.P.

Royal Crown Derby chinaware. ANON. *Ceram. Age*, **33** [2] 49 (1939).—A brief history of this ware is given. Illustrated. F.G.H.

Sixteenth-century Chinese vase. *Connoisseur*, **98** [423] 359 (1936).—Full-page color illustration of the vase which is of porcelain with engraved designs of lotus scrolls under a beautiful turquoise glaze. It has an ovoid body and short contracted neck and is from the Eumorfopoulos collection. M.E.P.

Staffordshire punch bowl. HELEN COMSTOCK. *Connoisseur*, **99** [424] 40 (1937).—This large bowl decorated with agricultural scenes has no identifying mark, but the modeling and the glaze details suggest the work of James Luckock at Turner's Staffordshire Pottery at the end of the 18th century. Illustrated. M.E.P.

"Three color" porcelain. HELEN COMSTOCK. *Connoisseur*, **98** [423] 357 (1936).—An exhibition of Chinese porcelains of the *san ts'ai* or "three color" group shown by Ton Ying includes a sculpture decorated in fine yellow, green, and aubergine. The Kuan-Yin, 45 in. high, is the finest of the porcelain figures of the K'ang-Hsi period (1662 to 1722). M.E.P.

Twentieth-century Venetian glass. EUGENE WRIGHT. *Arts & Dec.*, **50** [2] 14–16, 42 (1939).—Ever since 1866, the little island of Murano, in the Venice lagoon, has been trying to regain the world supremacy that it held in the 15th century. After years of painstaking work, the effort has been justified. Using duplicates of the ancient glassmakers' tools, it is producing a variety of ware of the highest quality. The work is unhurried and a worker may take as much as six months to produce a single chalice or vase. Illustrated. L.F.M.

Two pieces from the Exhibition of Contemporary American Ceramists. *Magazine of Art*, **30** [11] 686 (1937).—"Dusky Diana" by Annie Laurie Crawford and "Nude with Alligator" by H. V. Poor are illustrated. M.E.P.

Typical pottery of the gulf coast. ANON. *Ceram. Age*, **31** [3] 79 (1938).—Illustrated. F.G.H.

Wedgwood ceramic portraits. JOHN THOMAS. *Connoisseur*, **98** [419] 29–35 (1936).—Wedgwood popularized art by commercializing the portraits in pottery by renowned artists of the day. His Etruscan portraiture, whether on black basalt background or the varicolored jasper backgrounds, covered two continents, Europe and America. This article deals only with the European profiles and busts. Bentley, his partner at this time, deserves much credit for his aristocratic and royal contacts which explains the nature of many of the orders. The cosmopolitan range of portraits includes contemporary royalty, politicians, artists, and philosophers. The basalt, described by Wedgwood as a "fine black porcelain bisque of nearly the same properties with the natural stone," receives a high polish. Jasper, which was perfected by Wedgwood between 1775 and 1779, is sometimes referred to as a body when used in a mass or as a background, but when utilized for fine figures it is called "jasper paste." Sulfate of baryta, or cawk, was mixed with clay and finely ground flint by a secret formula. The charm of jasper is its daintiness of color; when white it is almost translucent. Illustrated. M.E.P.

Ellsworth Woodward. ANON. *Bull. Amer. Ceram. Soc.*, **18** [5] 179–80 (1939).

Yuletide drinking vessels. C. A. EDINGS. *Connoisseur*, **98** [423] 328–32 (1936).—According to the old English and German Christmas customs, various pottery or glass vessels of prescribed shape were created for special drinks. Illustrated. M.E.P.

BOOKS

Art of Glass. WILFRED BUCKLEY. Oxford University Press, New York. 286 pp. Price $3.00. Reviewed in *N. Y. Times Book Review*, April 2, 1939.—Examples of glass as it has been made through the centuries are pictured. Roman, Chinese, Persian, Italian, German, Dutch, English, and some French pieces of great beauty are photographed which show the dexterity of glassmakers. M.V.C.

Pottery of Santo Domingo Pueblo. KENNETH M. CHAPMAN. Laboratory of Anthropology, Santa Fe. 192 pp. Price $4.00. Reviewed in *Science News Letter*, **35** [1] 16 (1939).—Many color plates are the feature of this monograph. The beautiful Indian designs are shown in quantity, and soft colors give the precise tones of buff and brownish red seen on the Indian ware. The text analyzes the technology and decoration of the pottery. P.G.H.

Purpose in Design. A. DEFRIES. Methuen & Co., London, 1938. Price 21s. This book is a survey of the new movement in design and is intended to express the characters of twenty-six nations. Ceramics occupies a large proportion of the book. Photographic reproductions of pottery are included. The chapter on American art consists of only nine pages of which American ceramics occupies only about half a page. Mass production increases enormously the number of similar pieces, yet no machine is capable of devising the original model, and the best originals are always made by especially gifted craftsmen. The way to a real art lies in developing individuality. Constantly changing designs and the demands of new materials call more and more for skilled designers. D. emphasizes the fact that, for mass production, purpose in design and fitness for purpose are particularly necessary. A. B. SEARLE

PATENTS

Applying designs on ceramic articles by etching. PORZELLANFABRIK PH. ROSENTHAL & CO. A.-G. Ger. 670,378, Dec. 22, 1938 (July 13, 1935); VI/80*b*. 23.07.—A paste consisting of a high percentage of hydrofluoric acid with a mineral substance insensitive to HF, such as fluorite or titanium oxide, as filler is used for surface etching ceramic articles. The etching paste is applied to the article, dried, and washed off, and the deepened places caused by the etching paste are filled with coloring material or gold. D.A.B.

Coloring compositions for ceramics. DEUTSCHE GOLD- UND SILBER-SCHEIDEANSTALT VORM. ROESSLER. Fr. 832,401, Sept. 27, 1938; *Chem. Abs.*, **33**, 2668 (1939).—A color preparation for ceramic objects comprises a mixture of a ceramic color with a cellulose ester and a solvent for the cellulose ester. The mixture may also contain additions for modifying the fluidity or drying properties of the mixture or the stability of the dried color. The mixture may comprise NiO, CoO, diacetone alcohol, CH_3OH, C_2H_5OH, nitrocellulose, acetone, or Me acetate. The preparation is applied by projection.

Designs for:
Atomizer. F. A. VUILLEMENOT (DeVilbiss Co.). U. S. 114,571, May 2, 1939 (March 9, 1939).
Bottle. R. A. BLUNT. U. S. 114,745, May 16, 1939 (March 12, 1938). U. S. 114,746, May 16, 1939 (March 29, 1938). J. L. DUNNOCK (Swindell Bros., Inc.). U. S. 114,363, April 18, 1939 (Jan. 31, 1938). M. W. LOWENSTEIN. U. S. 114,368, April 18, 1939 (March 3, 1939). A. C. MEYER (Glenshaw Glass Co.). U. S. 114,763, May 16, 1939 (Dec. 2, 1938).
Combined coffee maker and teapot. W. B. MOORE. U. S. 114,550, May 2, 1939 (Jan. 19, 1939).
Combined light bracket and shade. J. W. BROOKS (Pass & Seymour, Inc.). U. S. 114,805, May 16, 1939 (Jan. 18, 1939).
Combined sink and cabinet. J. R. MORGAN (Sears, Roebuck & Co.). U. S. 114,643, May 9, 1939 (Nov. 18, 1938).
Combined sink and drainboard. J. R. MORGAN (Sears, Roebuck & Co.). U. S. 114,645, May 9, 1939 (Nov. 18, 1938).
Drinking glass. J. E. SPENCE (Hazel-Atlas Glass Co.). U. S. 114,690, May 9, 1939 (May 16, 1938).
Figurine. DORR BOTHWELL (Gladding, McBean & Co.). U. S. 114,747, May 16, 1939 (March 6, 1939).
Glass jar. F. J. PETTY (Ball Bros. Co.). U. S. 114,686, May 9, 1939 (March 8, 1939).
Glass tumbler. T. C. HEISEY (A. H. Heisey & Co.). U. S. 114,712, May 9, 1939 (Feb. 6, 1939).
Perfume atomizer. F. A. VUILLEMENOT (DeVilbiss Co.). U. S. 114,570, May 2, 1939 (March 9, 1939).
Perfume bottle. J. D. BUCKINGHAM (Lucien Lelong, Inc.). U. S. 114,360, April 18, 1939 (Feb. 13, 1939).
Plate. DOUGLAS BOURNE (Onondaga Pottery Co.). U. S. 114,670, May 9, 1939 (March 6, 1939). C. W. LEIGH (Morimura Bros., Inc.). U. S. 114,402, April 18, 1939 (Jan. 5, 1939). U. S. 114,452, April 25, 1939 (Feb. 2, 1939). U. S. 114,684, May 9, 1939 (Jan. 5, 1939). J. T. WIGLEY (Onondaga Pottery Co.). U. S. 114,573, May 2, 1939 (Sept. 27, 1938).
Sink. J. R. MORGAN (Sears, Roebuck & Co.). U. S. 114,640 to 114,642, May 9, 1939 (Nov. 18, 1938).
Sink cabinet. J. R. MORGAN (Sears, Roebuck & Co.). U. S. 114,644, May 9, 1939 (Nov. 18, 1938).
Tumbler. JEAN VIATOUR (Libbey Glass Co.). U. S. 114,568, May 2, 1939 (Sept. 10, 1938).
Vase. DORR BOTHWELL (Gladding, McBean & Co.). U. S. 114,748, May 16, 1939 (March 6, 1939).

Cements

Effect of calcination temperature and fineness of grind of gypsum on the quality of gypsum molds. N. K. ANTONEVICH. *Stroitel. Materialy*, **1938**, No. 4, pp. 63–65.—The characteristics of properties of freshly prepared gypsum must be determined from the content of hydrate water within 24 hr. The gypsum must be stored in dry condition. When calcining at 140° and 160°, gypsum molds must be maintained at these temperatures for at least 15 to 17 min. The best mechanical strength is obtained with plasters calcined at 180°, higher temperatures giving less favorable results. The water-absorbing capacity decreases with increase of the calcination temperature. P.B. & E.S.

Improvements of plaster molds. FELIX SINGER. *Brit. Clayworker*, **47** [563] 368–72 (1939).—The degree of porosity is of great importance in the plaster mold. The total absorption of the mold is proportional to the volume of the pores and is, therefore, in direct proportion to the quantity of water with which the plaster has been made up. The larger the air volume in the dried mold, the lower are its density and tensile and compressive strength. Molds should not be made up with less than 60% water. Such molds have a density of 73.5 lb./cu. ft. and a compressive strength of 2500 lb./in². Plaster molds made up of several pieces must be made so that each piece is of equal porosity. Trouble will be experienced with ware made in molds in which the pieces vary in porosity. The necessity of thoroughly mixing the plaster when preparing molds is pointed out and the use of mechanical stirring is recommended. Organic agents in casting slips cause much less deterioration of the molds than inorganic dispersing agents. R.A.H.

PATENT

Sintering cement, etc. FRIED. KRUPP GRUSONWERK A.-G. Ger. 668,460, Nov. 10, 1938 (April 14, 1934); V/80*c*. 13. D.A.B.

Enamel

All-gas operated vitreous enameling works. ANON. *Sheet Metal Ind.*, **12** [129] 71–72 (1938).—A description is given of the Greenwich works of National Enamels, Ltd., which has made a speciality of the products required by the gas industry. A.P.S.

Answers to important questions on enameling. L. STUCKERT. *Sheet Metal Ind.*, **12** [129] 73–74 (1938). A.P.S.

Art enameling. HIREN BOSE. *Indian Ceramics*, **1** [1] 12–14 (1938).—B. describes the various processes of art enameling in India and the Byzantine, Italian, and French methods. A.P.S.

Behavior of different kinds of sulfuric acid in the strip steel pickling plant. W. UFER AND A. DÖRING. *Stahl & Eisen*, **58**, 1107–11 (1938).—Laboratory and works trials were made of sulfuric acid for pickling from different sources (chamber and contact processes), with and without inhibitors such as sodium chloride or nitrate or nitrosylsulfuric acid. The differences noticed were slight. Technical sulfuric acid (15%) gave the best result, and the customary consumption of 10.0 to 10.6 kg. of 96% sulfuric acid per ton of steel strip was necessary. L.R.B.

Changes layout twice a day. E. F. GEHRIG. *Factory Management & Maintenance*, **97** [3] 72–74 (1939).—The problem of insufficient space for placing both enamel dip tanks and spray booths in fixed positions is solved by placing both on wheels. Dip tanks are used for ground coats and are then wheeled away and replaced by spray booths for cover-coat application. Material and product handling is solved by using a conveyer and rotary tables. Two photos, one chart. J.L.G.

Degreasing metal components with alkali cleaners. E. E. HALLS. *Sheet Metal Ind.*, **12** [131] 344–46 (1938).—H. discusses cleaning with alkaline agents *vs.* solvent methods and mechanical processes. A.P.S.

Development of sheet-iron ground enamels. RICHARD ALDINGER. *Glashütte*, **68** [35] 610–12 (1938).—The importance of the use of nickel or cobalt oxide for the adherence of enamels on sheet iron was not known before 1890, although at the end of the 18th century Sven Rinman used cobalt oxide in enamels for its coloring action. Before 1890 good adherence of the enamel coat was seldom obtained and enameled objects had to be cooled very slowly to prevent cracking. In 1891 Hubert Claus of Thale obtained a patent on adhering oxides; after that time their use spread quickly and made possible the great development of the enameled sheet metal industry. See "Historical—," *Ceram. Abs.*, **18** [6] 149 (1939). M.V.C.

Efficiency of enameling muffles. R. ALDINGER. *Glashütte*, **68** [39] 681–84 (1938).—Great progress in furnace construction in recent years has lowered maintenance and fuel costs. Higher efficiency can be secured in the operation of muffle furnaces by enlarging the muffle, better

utilizing the space in the muffle, reducing the weight of the grate and firing apparatus, and adopting tiered grates and the double-grate method. M.V.C.

Enamel defects, pickling defects, sheet-metal defects. RICHARD ALDINGER. *Glashütte*, **68** [52] 891–94 (1938).—Raw materials for enamel and for sheet metal are made with utmost uniformity of quality; cast-iron composition is tested in most manufacturing plants so that the cause of defects in enameling can seldom be attributed to defective raw materials. In 90 out of 100 cases defects in enameling originate during working when the slightest slip may have grievous results, as the defects do not appear until after the coat enamels are fired. In two specific cases (1) blisters appeared on the enamel at the edges and joints of handles; their cause was traced to improper pickling, milk of lime having been added to the first water bath instead of to the last to neutralize the acid and soaking having been inadequate; (2) cracks and blistered spots appeared in the lower part of the inside of pitchers; these were caused by insufficient firing which had failed to remove the oil applied to the unfinished ware before enameling. See *Ceram. Abs.*, **16** [8] 236 (1937). M.V.C.

Evolution of transfers suitable for vitreous enameling. P. S. MECRATE-BUTCHER. *Sheet Metal Ind.*, **12** [131] 351–54 (1938).—M.-B. describes the early days of development, by his firm, of ceramic transfers for firing on enameled iron. Drying, storage, application, and firing of transfers and the selection of colors are discussed. The largest size transfer produced is 29 in. x 39 in. M.-B. does not recommend a very large transfer; if the design makes it practical, suitable divisions can be made and the transfer supplied in two, three, or more portions. There is only one type of transfer suitable for application to vitreous enamel, *viz.*, a ceramic transfer printed in mineral colors to be fused into the enamel. The method of fixing recommended is described; special care is taken to see that no moisture is left between the transfer and the enameled surface. A.P.S.

Finishing machine has rotary spray. DEVILBISS CO. *Steel*, **102** [3] 58 (1938).—A new rotary spray finishing machine capable of an approximate production of 3600 small lightweight articles per hour is described and illustrated. H.E.S.

Formation of fish scales in enamels. WALTER KERSTAN. *Sprechsaal*, **71** [27] 335–38; [28] 347–53; [29] 359–63; [30] 372–73 (1938).—The smallest fissures in enamel are minute fish scales; all fish scales reach the sheet iron, and surface cracks may represent "deep" fish scales. The steel sheet used was studied chemically, physically, and metallographically. With respect to the chemical and physical nature of the sheet there were practically no differences. The metallographic study showed marked differences. When using the same enamel on different steel sheets, the tendency to form fish scales varied. Pickling for a longer time did not increase fish-scale formations. An addition of pickling solution did not markedly diminish defects. Sandblasting was more effective because the surface of the sheet was better cleaned. The muffle atmosphere has a strong effect. The presence of gases in the muffle is objectionable; carbon monoxide checks the formation of an adhering layer. Ground enamel may be made more resistant to the formation of fish scales with suitable mill additions. The optimum addition must be determined for each case by experimenting, and it depends on the composition of the enamel. Enamel not melted homogeneously (heterogeneously) is less liable to develop fish scales. Too long firing and too high temperatures promote their formation. Steel sheet treated in a vacuum showed fewer fish scales than that not treated. The calcining of sheets changes their structure; decarbonization develops carbon monoxide which may cause defects. The amount of absorbed hydrogen in the pickling solution and that developed during the enameling process have a great influence. The correlation existing between the escape of hydrated water from the clay and the escape of steam from the enamel slip has been explained by J. Klärding (*Ceram. Abs.*, **18** [1] 11 (1939)). Tensions present within the enamel layer, especially those produced by the layerlike structure of the ground enamel, may produce defects. The formation of crystals in the ground enamel leads to the formation of fish scale. The addition of alkali borates to the mill and a finely roughened sheet surface diminishes this formation. The formation of fish scales is due usually to several causes. M.V.C.

Gas clouding of enamel: I. ALFRED HORN. *Bull. Amer. Ceram. Soc.*, **18** [5] 188–89 (1939).

Heavy-oil burners reduce cost and produce better frit. ANON. *Sheet Metal Ind.*, **12** [129] 65 (1938).—Construction details are presented of Rotovac heavy-oil burners operating frit-making furnaces in the vitreous enameling plant of the Tividale Enamel Co., England. These burners, due to their atomizing properties, give frit outstandingly free from discoloration and contamination and save more than 23% in oil consumption. See "Unit—," *Ceram. Abs.*, **16** [8] 253 (1937). A.P.S.

Laboratory features elaborate equipment. AMERICAN ROLLING MILL CO. *Steel*, **102** [10] 84–85 (1938); see "Armco—," *Ceram. Abs.*, **17** [8] 292 (1938). H.E.S.

Manufacture and use of sheet iron for enameling. J. S. WALTON. *Sheet Metal Ind.*, **12** [133] 575–77 (1938).—The processes are described. **Discussion.** *Ibid.*, pp. 577–78. A.P.S.

Mechanism of mill-added opacity in porcelain enamels. A. I. ANDREWS AND B. W. KING, JR. *Jour. Amer. Ceram. Soc.*, **22** [6] 173–76 (1939).

Metal finishing processes. FRED W. VOGEL. *Products Finishing*, **3** [7] 7–19 (1939).—V. describes processes at the firm of Scovill of Waterbury, Conn. A photo and a description of electroplating of dies with 0.003 in. of hard chromium are given. Glass-enclosed fully air-conditioned enamel spraying booths are also described. H.K.R.

Monel metal solves the problem of economic pickling crates. N. C. MARPLES. *Sheet Metal Ind.*, **12** [132] 456–57 (1938).—M. describes the advantages of the adoption of Monel for pickling crates over wood and cast acid-resisting bronzes. In the pickling of hollow ware prior to enameling, Monel crates can be rotated after withdrawal from the acid bath in order to completely drain off the acid. Monel possesses excellent resistance to HCl and H_2SO_4 at the concentrations and temperatures commonly employed in pickling operations. A.P.S.

Pickling in a modern enameling plant. ANON. *Products Finishing*, **3** [8] 44–45 (1939).—The standard of enameling on present-day domestic cooking ranges is much higher than it was some years ago. This is due chiefly to more careful preparation of sheet-metal surfaces before enameling. Pickling is one of the key processes in preparing sheet metal for the enamel shop and it is now usually carried out under scientific control. The straight line system is employed in the works of Messrs. Sidney Flavel & Co., Ltd., Leamington, England, one of the oldest manufacturers of cooking ranges in this country. The degreasing tanks contain boiling trichlorethylene. The pickling solution used is cold muriatic acid at about 11% concentration, and the neutralizing solution is composed of soda and water maintained at about 150° to 160°F. Illustrated. H.K.R.

Pickling suitable for steel. P. DICKENS. *Stahl & Eisen*, **58**, 1343–46 (1938).—D. discusses the formation of scale and its dependence on temperature and furnace atmosphere and the use of sulfuric and hydrochloric acids as pickling agents for steel. Inhibitors are mostly colloidal and separate out or decompose if the temperature is raised. Rodine, adazide, and Vogel's inhibitor in quantities of 0.05 to 0.1% are used below 70°C; they restrict the attack about 95%. Pickling tanks are no longer lead lined for sulfuric acid or rubber lined for hydrochloric acid. Substitutes used include concrete (protected by asphalt brick), a mixture of Bakelite and asbestos, diabase, Ukrainian granite, and a sandstone, previously heated with oil. Monel metal and Duraloy are too expensive for general use. The influence of bath temperature and acid concentration on the pickling rate and the brittleness of the product, as well as electrolytic pickling, are discussed. L.R.B.

Porcelain enamel: life-long finish. E. L. STINE. *Products Finishing*, **3** [7] 48–52 (1939).—S. describes the manufacturing process for frit and enamel and enameling procedure. The specification for the proper base sheet iron, together with formulas for base and cover coats, is given. Methods of producing grain and marble finish and some new uses of enamel, *e.g.*, for the inside of the water manifold of automobiles, tombstones, burial vaults, and roofing shingles, are briefly described. See "Vitreous—," *Ceram. Abs.*, **17** [3] 97 (1938). H.K.R.

Possibilities of the application of the radiant-tube system to the vitreous enameling industry. A. A. STRAUB. *Sheet Metal Ind.*, **12** [130] 231–33 (1938).—The radiant-tube system of heating differs from the present methods as applied to fusing furnaces in that it operates essentially as an immersion heater; the fusing chamber proper is a thoroughly insulated box in which internally fired tubes are immersed, the external surfaces of which possess high heat emissivity and radiate directly onto the work as charged; they also set up convection currents which, if the tubes are properly applied and spaced, ensure thermal uniformity. The specific advantages are as follows: (1) the internal dimensions of the chamber are less than the dimensions of the heated section of an externally fired muffle; (2) the reduction in the superficial area of the external radiating surface, together with the lower temperature at which this surface is maintained, *i.e.*, within a few degrees of load temperature, reduces radiation losses by at least 20% as compared with standard muffle practice; (3) the elimination of large masses of refractory material, *e.g.*, between the source of heat generation and delivery, results in a reduction in time and fuel required for heating up and in a saving in fuel by the synchronization of heat generation with delivery, due to the elimination of time lag; one of the outstanding features of this furnace in practice is the remarkably rapid return to normal working temperature after the load is charged; (4) the tubular elements have stood the test of three years' continuous application under severe conditions. One of the natural advantages of this form of radiant-tube element as developed by the Lee Wilson Engineering Co. is its flexibility of application. It is equally applicable to batch and continuous furnaces. These tubes are generally fired by clean gas such as (in the U. S.) natural gas, coke-oven gas, ordinary city gas, cleaned bituminous gas, anthracite gas, or hot gas derived from the combustion of coke. **Discussion.** *Ibid.*, pp. 233–34. A.P.S.

Sag-resisting properties of enameling iron. FRANK R. PORTER. *Jour. Amer. Ceram. Soc.*, **22** [6] 176–79 (1939); see "Factors—," *Ceram. Abs.*, **18** [6] 148 (1939).

Structure of steel sheets. E. C. ROLLASON. *Sheet Metal Ind.*, **12** [133] 526–27 (1938).—Four factors to consider when examining the structure of steel sheets are (1) the number of microconstituents present, (2) size and shape of grains, (3) intrinsic properties of each phase, and (4) relative proportions by volume and distribution of each constituent. A.P.S.

Synthesis of colored enamels. R. ALDINGER. *Glashütte*, **68** [26] 437–39 (1938).—Colored enamels are obtained by (1) adding granulated coloring substances to the mill with water, clay, and the necessary amount of white opacifier, and (2) adding the coloring material to the batch and firing it with the enamel; the latter method is used only for dark-brown and black enamels and for majolica enamels for cast iron. The first method is simpler and cheaper, especially for delicate colors, because fewer enamels need to be fused and kept on hand and the colored enamels can be made in small quantities. Bright, rich colors are better obtained by fusing the color oxide with the batch, the disadvantage being the necessity of fusing every colored enamel separately. Some of the most important coloring substances for red, yellow, and brown (cadmium red, cadmium yellow, iron oxide) can not, however, be fused in the enamel without decomposing. Moreover, it is not necessary to melt the coloring substance in the batch; very rich, bright colors can be obtained by adding the coloring materials to the mill if a suitable enamel with little or no opacifier is selected for mixing with the colors. For making delicately colored enamels, an opacified white enamel with suitable expansion, resistivity, and fusibility is selected, and the desired colors are added to the mixture in the mill or, preferably, a small amount of a powerful coloring substance is introduced; by mixing several of the coloring substances, all possible colors can be obtained. The most expensive coloring substance usually proves to be the most economical. The fine grain size of the coloring substance is very important in obtaining a uniform color effect. For coarse-grained coloring materials, a more beautiful colored enamel with less coloring substance can be obtained by grinding a mixture of the clay, coloring substance, and white opacifier with about $^1/_{10}$ of the granulated enamel and water in a small mill from 10 to 20 hr. before combining it with the rest of the frit and water to be ground in the large mill to ordinary fineness. The coloring substance must be free from water-soluble constituents, especially sulfates and chlorides, which can cause efflorescences on the surface of the enamel. Some setting agents such as magnesium sulfate can also cause defects, although 0.2 to 0.5% of magnesia added to the mill or borax dissolved in hot water is a harmless setting agent. Most coloring substances for opaque colors (blue, green, rose, violet, and ivory) can be made with all good pre-opacified white enamels. If a high glaze is desired, cerium oxide is used as opacifier. Enamels opacified with large amounts of fluorine compounds are unsuitable for obtaining bright rich colors. Three sample recipes for colored enamels are given, the third being for edge enamels having a higher expansion coefficient. Brown enamels are usually colored with iron oxide coloring substances which also contain chrome oxide, zinc oxide, and alumina. Errors with brown enamels are most often due to their low resistance to heat, but the enamel composition is also responsible. A special enamel containing 2% to 5% fluorspar, lime, and magnesia is used for brown enamel, and iron oxide is often added to the melt to saturate the enamel with iron oxide. To prevent decomposition of the red-brown coloring substance, quartz, feldspar, or glass powder is sometimes added to the mill; this raises the resistance to heat of the enamel. Three sample recipes for brown enamels are given. Red enamels are now made with coloring substances containing cadmium and selenium. Selenium coloring substances acquire a fiery red color only in acid enamel with high silicic acid and boric acid content. Enamel composition and the firing are very important for obtaining good color. Red enamel batches are tabulated. M.V.C.

Synthesis and modification of enamels. RICHARD ALDINGER. *Glashütte*, **68** [44] 764–66 (1938).—Failure of a tested enamel formula is not always due to faulty composition but may result from careless work methods or unsuitable working conditions. Influencing factors are the mixing of the enamel, the fusing time and temperature, fineness of grinding, thickness of the coat, kind of drying, firing time, and temperature. The correct way to trace an error is to proceed with the original enamel and raw materials and remake the enamel with great exactness and careful supervision of every step of the manufacturing process. The error does not usually appear in the finished ware, but if it does, the raw materials must be tested and the enamel composition must be altered to eliminate the defect without appreciably changing the other properties. Such corrections and modifications are first calculated and then tested in small amounts. The correction of several defects in enamel formulas is illustrated by examples. M.V.C.

BOOK AND SEPARATE PUBLICATION

Lecture course on enameling iron: VII, Annealing and heat treatment of enameling sheets. INLAND STEEL CO. AND A. I. ANDREWS. Inland Steel Co., Chicago, 1938–39. 6 pp.—This is one of the most important phases of the special process for producing enameling sheets. Open annealing (normalizing) and box annealing are discussed, and a number of photomicrographs illustrating the ef-

fects of these processes upon the internal structure of the enameling iron is presented. **VIII, Laboratory control, tests, and inspection.** 6 pp. The latest devices for securing uniform control over the various stages of the making of enameling sheets are described and discussed. Temper, as measured by hardness and ductility tests, is a satisfactory guide to suitability of iron sheet. Tensile strength and per cent elongation are determined, and enamel adherence is checked by impact testing of standard ground coat sheets. The microscope is used in checking the grain size of the iron in the sheets and the number, size, type, and distribution of inclusions that may affect the performance of the metal in fabrication. **IX, Enameling sheets for special requirements.** 5 pp. A group of case studies shows how product improvements and lower manufacturing costs are being secured through the use of sheets especially adapted to specific purposes. The flatness of panels in the finished product has received particular attention due to the demand for large sheets for signs, architectural purposes, and panels for display cases. One-coat ware production, to be successful, requires a high-grade enameling-iron sheet. The drawing problems incident to fabrication further complicate the production of enameling-iron sheets. **X, Cleaning shapes for enameling.** 5 pp. Grit blasting is not suitable for enameling sheets because the grit tends to embed itself and causes copperheading in the ground coat. The methods of sandblasting discussed include hand operation, automatic blasting, and centrifugal blasting. Scaling is a more costly operation than chemical cleaning and is seldom used except where strains in the iron require annealing. Chemical cleaning is a washing process in which a boiling alkaline soap solution is used to remove drawing compounds and dirt from the metal shapes. Emulsification, saponification, and scrubbing in cleaners are discussed. The process of electrolytic cleaning is accelerated by the flow of an electric current through the bath. A sulfuric acid solution of 5% to 8% at a temperature of 140° to 150°F is generally used as the pickling solution. Inhibitors are added to the pickle solution to reduce further attack of the acid on the metal. Iron sulfide pickle is used in the preparation of grayware. Nickel dip reduces copperheading and fish-scaling and improves adherence. Neutralizing and rinsing operations are important steps in the preparation of iron for enameling. **XI, Special developments in enameling work.** 7 pp. Superopaque enamels can be applied in thinner coats and are often used as one-coat enamels. Finer grinding and larger mill additions of opacifiers are being combined in the manufacture of new superopaque enamels. The acid resistance of enamels has received considerable attention because of the standard test developed by the Porcelain Enamel Institute. The development of leadless cast-iron enamels has been advanced. Practically all wet process cast iron ground coats are of the semifused type. Low fusing sheet iron ground coats have been developed and are a great aid to the enameler. Tin, zirconium, titanium, and antimony opacifiers have been improved. Gas opacity, although used commercially in Europe, has not reached plant production stages in the U. S. **XII, Properties of enamel surfaces.** 7 pp. The surface properties of enamels are divided into three general groups: (1) chemical, including resistance to acids, alkalis, weather, steam and hot water, organic chemicals and oils, and scumming; (2) physical and thermal, including resistance to abrasion, pinholes, and thermal shock, smoothness, and thermal conductivity; and (3) optical, including reflectivity, color, gloss, and refraction which are important to the beauty and covering power of enamels. **XIII, Trends of the enameling industry.** 7 pp. From a rule of thumb industry in which secrecy was regarded as a necessary defense against competition, enameling has developed into an industry in which science and the exchange of knowledge are constantly developing progress. For Parts **I–VI** see *Ceram. Abs.*, **18** [4] 94–95 (1939). F.J.Z.

Metal degreasing by the I.C.I. degreasing process. IMPERIAL CHEMICAL INDUSTRIES, LTD., London, 1938. 1st ed. Price 3s 6d net.—Full details of the performance, operation, and maintenance of the latest standard plants in the I.C.I. range are given, and special models designed to meet specific degreasing requirements are described. The chief points to be observed when installing degreasing plants are discussed, and detailed instructions for the operation and maintenance of all standard types are given.

A. P. SOM

PATENTS

Dry enameling processes. I. KREIDL. Brit. 503,934, April 26, 1939 (Oct. 15, 1937).

Method and apparatus for desurfacing ferrous metal bodies. J. H. BUCKNAM (Linde Air Products Co.). U. S. 2,157,095, May 9, 1939 (Oct. 24, 1936).—The process of thermochemically desurfacing a ferrous metal body comprises impinging a plurality of oxidizing gas streams upon a region extending across a surface of the body when at the oxygen ignition temperature, the streams being applied through nozzles arranged to supply gas in relatively large volumes at acute angle to a plane tangent to the surface being removed in the region of impingement and in the general direction of advance of the desurfacing reaction, inclining the streams mutually toward each other by orientations through angles of 5° to 20° about axes substantially perpendicular to the tangent plane, the orientation having a direction and magnitude such as to derive an external component of force supplementing the normal cohesive forces which operate in the surface of the reaction puddle that forms in the region impinged by the oxidizing gas streams to an extent which causes the reaction puddle to move centrally ahead of the reaction zone with little liability to sloughing off at the sides, and imparting relative motion to the plurality of oxidizing gas streams and the metal body.

Opacifiers for enamels. HARSHAW CHEMICAL CO. Fr. 832,759, Oct. 3, 1938; *Chem. Abs.*, **33**, 2672 (1939).

Porcelain enamel. FERRO ENAMELS (Australia) PTY., LTD. Australian 105,710, Nov. 17, 1938; *Chem. Abs.*, **33**, 2672 (1939).—Frit raw materials are continuously introduced at one end of a melting chamber having an inclined hearth; the material is melted by means of a flame projected in loop fashion over the hearth from a point at its lower end; the flow of the melted material is reversed through a fining chamber maintained at a lower temperature; and the fined material is discharged into a water bath. A furnace is described in detail.

Porcelain enamel. FERRO ENAMELS (Australia) PTY., LTD. Australian 105,711, Nov. 17, 1938; *Chem. Abs.*, **33**, 2672 (1939).—The raw material is melted during its flow over an inclined hearth by means of a looped flame directed angularly across the direction of flow and is then fined by causing the material and the flame to move in counterflow relation. A furnace is described in detail.

Producing vitreous enameling stock, etc. G. L. VON PLANCK. U. S. 2,158,443, May 16, 1939 (Nov. 18, 1936).

Glass

All-mirror wall and glass murals in Chicago restaurant. ANON. *Bull. Amer. Ceram. Soc.*, **18** [5] 177 (1939).

Architectural uses of glass. Y. P. VARSHNEY. *Indian Ceramics*, **1** [1] 3–6 (1938).—At present, almost the entire Indian demand for glass used in buildings is for window glass. V. gives various uses for glass in the building industry and for decorative illumination in India.

A.P.S.

Bubble formation in glass during flame working. J. ENSS. *Glastech. Ber.*, **14** [7] 255–56 (1936).—An analysis of a number of bubbles formed by working a simple soda-lime glass in an ordinary gas flame showed the presence of H_2 alone. The proposed explanation is the formation of hydrides at lower temperatures which decompose at higher temperatures, leaving the H_2 trapped under the fused surface. The bubbles formed when using

a CO flame were much smaller and more difficult to work with. In three cases, O_2 was the only gas present. Electric heating eliminates bubbling. J.F.H.

Color-producing component in selenium-red glass. H. LÖFFLER. *Sprechsaal*, **71** [33] 406–408 (1938); translated in *Glass*, **15** [10] 396–99, 406 (1938).—During the first fusion processes of selenium-ruby glass there sometimes occur separations of liquid phases composed mainly of sulfides and selenides of cadmium and zinc with minor amounts of alkali. By studying the origin and further behavior of these liquid phases, L. made important disclosures. The separations from selenium ruby glass batch which consisted mainly of CdSe, ZnS, and alkali selenide are described. In the manufacture of selenium-ruby glass, selenium colored more strongly when introduced in the form of cadmium selenide than in any other form. By using cadmium selenide, up to 66% selenium and 75% cadmium can be saved in contrast to mixtures of CdS and Se. With the use of CdS and Se, the formation of color-producing components in selenium-ruby glass results in a two-phase reaction, selenium being lost in both phases and cadmium in the second. Sulfur in sulfide form is necessary for the formation of a pronounced selenium-ruby color. Deficiency in sulfide gives brown color tones. Sulfur can be introduced as a sulfide of cadmium, zinc, alkalis, antimony, tin, arsenic, and iron, each of which has a definite effect. Best results are obtained when the sulfide is introduced in the form of potassium thiocyanate (or sulfocyanate) which, by means of its reducing action, simultaneously removes defects caused by sulfur. The liverlike appearance of selenium ruby can be caused by the growth of the coloring crystals through a transformation of the crystals into tiny drops with the absorption of alkalis and zinc. The color-producing components of selenium-ruby glass consist of a mixed crystal of CdSe and CdS in which the content of CdS should not be less than 18%. The composition of color-producing components can be determined by analysis. M.V.C.

Cutting of glass and weakening of the glass through the cut. H. JEBSEN-MARWEDEL AND K. VON STÖSSER. *Glastech. Ber.*, **17** [1] 1–11 (1939).—An essential feature of the cutting operation is the formation of a perpendicular fissure penetrating the body of the glass in which glass particles become wedged. As shown by Holland and Turner (*Ceram. Abs.*, **17** [1] 11 (1938)), the cut is accompanied by a strain pattern which penetrates deeper with increasing load and becomes smaller with aging. Calculations show that a load of 500 g., which is usual in hand cutting, furnishes a pressure in excess of that needed to groove the glass. The loads needed to complete the cut were determined by loading the 180 mm.-square glass plates supported on knife edges 162 mm. apart. The curve of breaking load plotted against glass thickness for hand cutting done by an experienced worker gives values of approximately 3, 6.5, and 12 kg. for 2, 3, and 4 mm. thicknesses, respectively. The use of petroleum oil in hand cutting had the apparent effect of reducing the breaking load needed by about 10%. Mechanical cutting with a device for constant load, however, failed to distinguish between fresh cuts made dry or wetted with water or oil. On aging, there is a gain in strength of around 30%, although the strength is still far below that of unscored glass. Wetting with water or oil has little or no effect on the certainty of the break following the score mark. The apparent lowering of the breaking load in hand cutting due to use of oil may be the result of applying greater load because of lower friction. J.F.H.

Danger common to the iron and refractory parts of a glass-furnace structure. ANON. *Glashütte*, **68** [38] 668–69 (1938).—The framework of a tank furnace for melting glass is constructed of iron which, if not adequately protected, flakes off and is reduced to ferrous oxide. The latter damages the refractories as follows: the silicic acid of the refractories combines with FeO; ($2FeO \cdot SiO_2$) is formed as well as a eutectic mixture, with FeO on the one hand and $FeO \cdot SiO_2$ on the other, which is liquid at 1065° and forms a dark-brown or olive-green slag. While this destruction is taking place, another reaction occurs on the entire inner surface of the refractories as follows: sulfur present in the furnace gases and flue dust from the frit form a deposit with a high alkali content which, because of a low eutectic, causes scorification and enlarges cracks. Both processes acting together cause great damage. M.V.C.

Determination of iron in glass raw materials. THÜRMER. *Glashütte*, **68** [50] 857–58 (1938).—Different methods for determining iron in glass raw materials yield different results with the same raw materials. The analytical method is rapid and clear. The colorimetric and titrimetric methods are compared. M.V.C.

Determination of sand and glass in the glass batch. N. A. FREZE. *Zavodskaya Lab.*, **7**, 869–70 (1938).—The mixture is placed in aqueous $KI\text{-}HgI_2$ (density 2.54), wherein SiO_2 sinks and glass powder floats. P.B. & E.S.

Development of machines, suited to German economic conditions, for the manufacture of glass containers. H. SEVERIN. *Glastech. Ber.*, **17** [2] 38–45 (1939). J.F.H.

Devitrification and corrosion. ZSCHACKE. *Glashütte*, **68** [45] 777–78 (1938).—Three types of changes occurring in glass are (1) devitrification, which takes place in the interior of the glass at high temperatures only; (2) surface changes, caused by the corrosive action of flue gases and the formation of deposits on the surface of the glass, which occur only in the annealing furnace; and (3) erosion by moisture on the surface of the finished glass at room temperature or a little above. Devitrification occurs readily in hard glasses with high lime content; erosion or weathering occurs in very soft glasses with high alkali content. Increasing the lime content lowers resistivity to devitrification and raises the resistance to water erosion; increasing the alkali content increases resistance to devitrification and decreases resistance to water or moisture erosion. The process of devitrification is described as follows: when sand, soda, lime, and the other ingredients of glass are fused, silicates are formed; the natural state of many silicates is crystalline, with the silicon, calcium, and oxygen occupying very definite positions in the lattice. These components are so interdependent that they can not change their position without destroying the crystal lattice. All compounds strive to maintain this state, a state of the greatest order and rest. Heat usually destroys the crystal lattice; the components are disarranged, and a liquid is formed. Slow cooling usually re-establishes the old arrangement (which can take place only in a liquid state), and the melt crystallizes. Sudden solidifying does not give the components sufficient time to assume their customary arrangement, so that what results is not glass but a devitrification. M.V.C.

Effect of fining agents on coloring and decolorizing agents for glass. L. SPRINGER. *Glashütte*, **68** [47] 812–13 (1938).—The effect of saltpeter and arsenic on a soda-lime glass (150 sand, 24 marble, 15 potash, 50 soda) and a potash-lead glass (150 sand, 50 minium, 50 potash, 15 soda) in the presence of (1) nickel and cobalt oxide, (2) chrome and uranium compounds, and (3) copper compounds was studied. Results are as follows: (1*a*) In a soda-lime glass with nickel oxide alone, the color was violet with a brown tinge; with saltpeter, the color was less violet and more wine red. Arsenic causes the complete disappearance of the violet color, and the glass becomes gray with a reddish tinge. (*b*) In the potash-lead glass only blue violet was obtained. (*c*) Both soda-lime glass and potash-lead glass showed no change with the addition of saltpeter and arsenic, although further study may disclose a stronger action with stronger oxidizing or reducing agents. (2*a*) In soda-lime glass with chrome compounds, the addition of saltpeter had no effect except to slightly deepen the yellowish color; arsenic changed the color to green. In potash-lead glass such differences were not observed. (*b*) Soda-lime glass with uranium compounds and no additions was yellow with a green tinge, with the addition of saltpeter, it became distinctly more yellow. Arsenic had no effect. (*c*) The lead glass without additions was a deeper yellow than the lime glass and additions showed no apparent change. (3*a*) Soda-lime glass with a small copper oxide addition was blue with

a greenish tinge; a potash-lime glass was similarly but less intensely colored; potash-lead glass was also similar though with less of the greenish tinge. (*b*) The addition of three parts saltpeter to the soda-lime glass with one part pure red copper oxide also gave a blue color with green tinge; with the addition of 0.5 part arsenic the color disappeared, leaving only red striae. The same glass with copper hammer scale and the addition of saltpeter and arsenic gave deep blue. The potash-lead glass with copper oxide and arsenic was lighter than that without this addition. Saltpeter usually had an oxidizing effect and arsenic had a reducing effect on glasses colored with copper compounds. M.V.C.

Evolution of the use of raw materials for opacifying glass. RUDOLF SCHMIDT. *Sprechsaal*, **71** [48] 585–88 (1938).—S. reviews the literature dealing with the use and change in development of opacifiers for glass. M.V.C.

Explanation of the melting down of glass mixes. ANON. *Sprechsaal*, **71** [30] 373–74 (1938).—The changes which take place in the piled-up glass mix when it first begins to melt down are as follows: A fused crust is formed on the surface where reactions are brought about by the radiating furnace heat. This crust soon prevents the free escape of gases from the interior and they break violently through the crust raising blisters. Simultaneously the first fused aggregate begins to run down the sloping sides of the pile. Sampling of this fused aggregate almost invariably shows that practically the total sand is dragged down with the fused alkalis, so that no essential variation in the average value exists, and that the specific gravity of the sand and the melt do not differ radically. The crust on the piled-up mix is not composed of consitutuents with low flux content but of a fresh layer of the normal and complete batch which is exposed until the normal liquid melt runs off. The entire mass melts down normally and homogeneously; the residual sand "swims" in the melt and is carried along by it until it is gradually dissolved. M.V.C.

Flat arches in glass-furnace construction. MAX SCHNEIDER. *Glashütte*, **68** [24] 405–408; [26] 442–44 (1938).—S. discusses the characteristics, purpose, and conditions of use of flat arches in the construction of glass furnaces and gives rules for their construction. M.V.C.

Glass etching. HANS SCHULZ. *Glashütte*, **68** [48] 828–30 (1938).—The extent and type of etching action of hydrofluoric acid and its salts depend on the composition of the etching bath and the active salts contained in it, the temperature, and the composition of the glass. A 40% watery solution of hydrofluoric acid is used. Ammonium fluoride, potassium fluoride, and sodium fluoride are mixed to reinforce the action of the mineral acids. The grain size, which determines the strength of the etching, can be greatly influenced by alkali chloride or alkali sulfate. According to Hesse, the soluble fluorides can be transformed by alkali chloride or sulfate into the insoluble double fluorides which settle as tiny crystals on the surface of the glass and prevent the etching of the acid in these places. Only the glass surface between these places is dissolved; the cavities deepen and widen in time, eventually covering the entire surface. A mixture of wax and paraffin or asphalt is used to protect the surface of the glass which is not to be etched; it has the right consistency for marking with the graduating needle. The degree of hardness of this layer depends not only on its composition but also on the method of application which may be either by melting or in solution, with oil, turpentine, or chloroform as solvents. Baryta and lead glasses and alkali-lime glasses take a good mat etching. Alkali borosilicate glasses show only "clear" etching. M.V.C.

Glass industry in Germany. ANON. *Ceram. Age*, **32** [3] 76–77 (1938).—The trends are observed. F.G.H.

Glass industry in Rumania. SHELDON T. MILLS. *Ceram. Age*, **32** [4] 118–19 (1938).—M. gives a brief survey. F.G.H.

Glass safeguards time-capsule contents. ANON. *Ceram. Age*, **32** [4] 107–108 (1938).—The inner crypt of the time capsule is made of Pyrex brand glass. Illustrated. F.G.H.

Glassworker. History of people engaged in glassmaking and glassmaking shops. J. BLAU. *Glastech. Ber.*, **17** [2] 46–48 (1939). J.F.H.

Good and poor hollow glassware. ZSCHACKE. *Glashütte*, **68** [40] 698–99 (1938).—Hollow glassware (vessels and bottles) which comes in contact with liquids must be of high quality to withstand the dissolving action of its contents. The alkali compounds in glass are easily soluble in water; alkaline-earth compounds and silicic acid are difficultly soluble, although alkali hydroxide and alkali carbonate liquids dissolve silicic acid to form alkali silicates. The higher the alkali content of a glass, the more easily it is dissolved; the lower the alkali content, the more stable the glass is to the dissolving action of water. Water coming in contact with the surface of the glass dissolves the alkali present. The alkali-silicic acid compounds split off as alkali hydroxide and silicic acid hydrate are formed. This process is called hydrolytic cleavage. In a good glass with low alkali content, the dissolving action is soon arrested because the silicic acid liberated from the alkali absorbs water and swells, closing the holes and preventing further penetration of water into the interior of the glass. In ascertaining the stability of glasses by dissolving tests at ordinary temperatures, a definite quantity of alkalis is found in the first dissolving solution by titration with acid solution, but in further tests a great decrease in the quantity of alkalis dissolved out is observed. Glass with larger alkali content shows greater alkali erosion, and the swelling of the silicic acid is inadequate to protect the interior of the glass until after washing 5 or 6 times with fresh water. Poor glasses with high alkali content can not be used for containers because their surface becomes eroded and not only alkali impurities but also particles of silicic acid contaminate the contents. The action of alcohol and other solutions on hollow glassware and the effect of high temperature are explained. When the surface of the glass becomes coated with foreign deposits such as salts from hard water, but the surface of the glass itself is unimpaired, a weak solution of HCl will easily remove them. M.V.C.

High-test safety glass. ANON. *Bull. Amer. Ceram. Soc.*, **18** [5] 176 (1939); *Ceram. Age*, **33** [5] 148-49 (1939).

History of phosphate glasses. GANZENMÜLLER. *Glashütte*, **68** [51] 873–75 (1938).—Because of the secrecy with which recipes and methods of making glass were kept, the true discoverer of new raw materials for glass was seldom known. Phosphate glasses were probably first made in the 14th century. A treatise from Florence, Italy, written at the end of the 14th century, gives the following recipe for an opaque red glass: 6 lb. glass of "Syrian alum," 2 lb. glass of white wine stone, 9 oz. burned white bone, 5 oz. Cyprus vitriol, 9 oz. copper hammer scale, and some iron hammer scale. A recipe from a Bologna treatise of the 15th century is 1 lb. crystal, 5 lb. deer bones (buffalo or ox bones may be substituted), and 5 lb. alkali. In 1669 the alchemist Joh. Joach. Becher hints guardedly of bone glass in his work "Physica Subterranea." In his work "Ars Vitraria Experimentalis," 1689, Kunckel in Germany lists bone glass recipes which he obtained from Daniel Kraft, a glass technician of Mainz, who was thought to be among those who unsuccessfully sought a recipe for porcelain. Kunckel also used human bones in his bone glass which gave an especially fine white glass. In the second half of the 17th century the forgotten Italian recipes for bone glass reappeared in the search for the secret of Chinese porcelain. In 1725, R. A. F. Reaumur tried to make a substitute for porcelain by artificially causing devitrification of glass. G. gives a number of formulas, with directions for making bone glass, colored phosphate glass, and alabaster glass, used between 1796 and 1845, including some originated by Vinzenz Pohl of Neuwelt. M.V.C.

Infection of slag wool by fungi. E. E. FRAÏFELD. *Stroitel. Materialy*, **1938**, No. 6, pp. 39–40.—In very moist air, fungi may develop in slag wool, increasing its moisture content and changing its structure, *i.e.*, its thermal insulating properties, by transforming it to powder. P.B. & E.S.

Influence of the level of glass and temperature variation on glassware in the tank furnace. H. BAUMER. *Sprechsaal*, **69** [2] 18 (1936).—Proper construction of the tank furnace and very careful operation are necessary to produce a glass in a tank furnace of the same high quality as that made in pot furnaces. Homogenizing the glass in a tank furnace is more difficult because mechanical mixing is unfeasible; the temperature must therefore be maintained at the proper heat during fusing, refining, and working. Practice shows that a higher level of glass is more favorable and that the influence of stagnating layers of glass is always present even at lower levels. The harmful effect of deep layers of glass on the quality of the fresh glass is not dependent on the height of the glass level since these layers no longer participate in the flow. Only when the furnace is too hot does damage occur; the deep layers of glass become soft and begin to flow with the rest. With a higher level the flowing layer of glass becomes larger, which brings about a retardation of the velocity of flow. When fusing glass in a tank furnace at a deeper level, more time for refining and cooling is necessary, *i.e.*, with similar length of the flow passage from hearth to work room the glass remains at the necessary temperature for a longer time. A further advantage of a deeper glass level is that the tank bottom lasts longer and the heat loss by radiation from the bottom of the tank is less. Tank depth for hollow glass varies between 75 and 120 cm. and is sometimes deeper. The depth of flow (calculated) is about 45 cm., with a tank depth of 120 cm., and 30 cm., with a tank depth of 75 cm. Good decoloring of glass is obtained in a tank furnace. Nickel, selenium, and cobalt are the best physical decoloring agents. Saltpeter and arsenic are used for chemical decoloration, but for best results both methods are combined. In tank furnaces, the glass frequently becomes difficultly fusible because of the absorption of alumina from the tank block. Another common defect in glass manufactured in tank furnaces is seeds; these frequently appear when more glass is handled than the capacity of the tank allows, the glass not having time to become completely refined. Seeds may also be caused by too short a refining chamber in relation to the fusing tank or improper regulation of the temperature curve for the length of the fusing tank. The glass flow is conditioned by the temperature of the glass mass. If the refining tank is too hot so that the temperature curve rises too abruptly, the glass flows back. In tanks with "bridges," the latter will remain pressed in position when the glass is flowing normally but wander from position when the glass flows backward. Defective glass is caused mainly by faulty firing, but once the proper temperatures are determined and maintained, a good quality of glass can be obtained. M.V.C.

Manufacture of filter glass transmitting infrared rays: I. TAKASI MORI AND HIDEO SETOGUTI. *Repts. Imp. Ind. Research Inst., Osaka, Japan*, **18** [11] 49 pp. (1938).—The authors prepared glasses of varying percentages and containing different coloring agents. The composition of the basic glass was 1.2 K_2O, 0.8 RO (CaO, ZnO, BaO, PbO, or B_2O_3), and 6 SiO_2, and the coloring agents were Mn_2O_3 3, 6, and 12%; Cr_2O_3 0.1, 0.5, and 2.5%; and CuO 0.01% and 0.05%. The ability of each glass to transmit infrared rays was determined. Mn_2O_3 is the most effective coloring agent for filter glass transmitting infrared rays, with Cr_2O_3 next. Conclusions are as follows: (1) The addition of Mn_2O_3 increases the absorption of visible rays and the shift into the infrared portion. When 12% Mn_2O_3 is added, rays of 1.1-μ wave length are transmitted by PbO, ZnO, BaO, B_2O_3, and CaO glasses (in decreasing order). (2) Glass containing 2.5% Cr_2O_3 is devitrified; the determination can not be made. Increasing the Cr_2O_3 content does not decrease transmitting ability. BaO and PbO glasses transmit well. (3) The addition of 0.01% CuO has no effect. The durability of each specimen was determined. Y.K.

Nature of pressed glass surfaces. F. OBERLIES AND A. DIETZEL. *Glastech. Ber.*, **17** [2] 45–46 (1939).—Under careful microscopic examination a pressed glass surface has the appearance of a plastic mass that has been pressed at random with a needle point to a depth of a few microns. This is in contrast to the picture presented by Jebsen-Marwedel (*Ceram. Abs.*, **16** [1] 16 (1937)) which consisted of sharp crests and rounded troughs, suggesting sticking to the mold at various points. The discrepancy is due to the fact that slight differences in illumination greatly alter the appearance. Experiments in coöperation with Jebsen-Marwedel confirm the work of the authors. J.F.H.

Norwegian glass industry. ANDREW W. EDSON. *Ceram. Age*, **32** [1] 13–14 (1938).—The types of glass produced in the five glassworks of Norway are briefly described. F.G.H.

Phosphate glasses. OSCAR KNAPP. *Glashütte*, **68** [45] 778–81; [46] 794–97 (1938).—Phosphoric acid is a very useful ingredient in glasses. It gives valuable optical properties, opacifies glass of special composition, renders glass permeable to ultraviolet radiation, serves as a foundation glass for luminescent glasses, improves the chemical resistivity to metallic vapors, raises the softening point in some cases, lowers the coefficient of expansion, and has many applications and possibilities for future uses. Although phosphoric acid is grouped with new oxides and has not been considered as belonging to the group of classic oxides (which includes silicic acid, potash and soda, lime, magnesia, and alumina, known to glassmakers for hundreds of years), a historic study of phosphate glasses shows that it is also a classic oxide. In 1689 bone ash was mentioned as an ingredient of an opaque glass batch by Johann Kunckel in his book "Ars Vitraria Experimentalis"; it had been used long before that time, although it was not known that bone ash contained a phosphorus compound (tricalcium phosphate, $Ca_3(PO_4)_2$). Phosphorus was discovered by Brand in 1676. A bone glass batch given by Kunckel in 1689 contained 60 sand or flint stone powder, 10 bone ash, and 40 refined potash. The chemical composition of this glass as calculated by Zschimmer was 64.5% silicic acid, 25.7% potassium oxide, 5.9% calcium oxide, and 3.9% phosphorus pentoxide. The bone ash of that time doubtless contained more organic matter than it does today because of incomplete ashing, and therefore the lime and phosphoric acid contents were lower and the alkali content was higher. Because of its beautiful white porcelainlike color, bone glass was very popular. K. gives other recipes, explaining their defects. The first systematic research on phosphate glasses was made by O. Inwald in 1899 and his findings are given. The defects and correction of later phosphate glass batches are discussed. M.V.C.

Practical electric discharge lamps: general applications and recent advances. L. J. DAVIES. *Trans. Illum. Eng. Soc.* [N. Y.], **31** [1] 49–66 (1936); *Jour. Soc. Glass Tech.*, **20** [79] 233A (1936).—Existing lamps are classified. The primary factor determining design is the filling gas used, and in practice the only gases used are mercury, sodium, or neon; of these, sodium is used as a high efficiency source regardless of color, and neon is used because it is a colored light source of high efficiency for its particular color. Mercury plays a dual rôle, its complete visible radiation providing a light source of high efficiency and its component lines being isolated by means of colored glass filters.

Protection of light-sensitive medicinals with colored glasses. J. EISENBRAND. *Glastech. Ber.*, **17** [1] 11–16 (1939).—Recent papers on the subject are discussed in detail. Satisfactory rapid test methods, by various authors, for evaluating glass are tabulated. The problem of producing completely satisfactory light-protective glasses is not considered solved. Certain dark green and red glasses are outstanding but are too expensive. J.F.H.

Scientific value of illuminating tube glasses. SCHAD. *Sprechsaal*, **71** [39] 479–80 (1938).—S. reviews the requirements and service of illuminating tube glass (clear, opaque, filter, and luminescent glass tubes). M.V.C.

Shattering of glass by detonation. E. REXER. *Glastech. Ber.*, **17** [2] 33–38 (1939).—Lead azide with a detonation velocity of about 5000 m./sec. was detonated in contact with the glass samples. Radial and concentric

breaks were simultaneously produced in glass plates. Under suitable conditions, a periodic shattering of the glass rods results, with intermediate zones free from cracks. Examination of the broken surfaces shows that the breaks are largely due to tension. The results are presented photographically. J.F.H.

Silvering glass. F. E. J. Ockenden. *Jour. Sci. Instruments*, **15** [6] 206–208 (1938).—The silvering component solution is silver nitrate 1 oz., distilled water 8 oz., and just sufficient ammonia to redissolve the brown precipitate which forms as the ammonia is added. Directions are as follows: filter, dilute to 16 oz. with distilled water, and store in a clean, dark, glass-stoppered bottle. Prepare the reducing solution (Rochelle salt $^1/_{40}$ oz., distilled water 10 oz., silver nitrate $^1/_{100}$ oz.) as follows: boil the Rochelle salt dissolved in distilled water, add silver nitrate, boil until a heavy gray precipitate forms, cool, and filter. Dilute the solution to 16 oz. with distilled water and store in a glass-stoppered bottle. Silver by immersing the cleaned object in a mixture of equal parts of the two solutions, each diluted with an equal volume of distilled water. Detailed instructions are given for cleaning the object in concentrated nitric acid and for mixing the components of the silvering solution. J.L.G.

Simplification of the calculation of batches and compositions of glass from tables with conversion factors. Anon. *Sprechsaal*, **71** [45] 547–50 (1938).—A question often arising in the glass plant is what glass composition will be obtained from a given batch mixture or what batch mixture yields a certain glass composition. Textbooks give theoretical calculations and conversion factors, but only for a definite amount and not multiples of this amount such as are here presented in convenient tables. Data are given for the simple calculation of the raw material figure from the glass oxide content, *e.g.*, SiO_2 from sand (no conversion factor exists for sand because practically all of it is introduced in the melt), Na_2O from soda, Na_2O from sulfate, K_2O from potash, Na_2O from Na saltpeter, K_2O from K saltpeter, CaO from lime, CaO and MgO from dolomite, BaO from baryta, PbO from minium, and Na_2O and B_2O_3 from borax. Figures are also given for calculating the glass oxide content from raw material figure, *e.g.*, sand (SiO_2), soda (Na_2CO_3), sulfate (Na_2SO_4), potash (K_2CO_3), saltpeter ($NaNO_3$, KNO_3), lime ($CaCO_3$), dolomite ($CaMg(CO_3)_2$), baryta ($BaCO_3$), minium (Pb_3O_4), and borax ($Na_2B_4O \cdot 10$ aq.). Examples are given. M.V.C.

Suggestions for writing batch specifications. John E. Boyd. *Bull. Amer. Ceram. Soc.*, **18** [5] 187–88 (1939).

Ultra high-speed photographic study of glass fracturing. Anon. *Bull. Amer. Ceram. Soc.*, **18** [5] 171 (1939).

X-ray study of boric oxide-silica glass. J. Biscoe, C. S. Robinson, Jr., and B. E. Warren. *Jour. Amer. Ceram. Soc.*, **22** [6] 180–84 (1939).

SEPARATE PUBLICATION

Glass kitchen. *Glass Container Assn. Booklet*, 12 pp.; *Ceram. Age*, **32** [2] 37–38; [5] 155 (1938).—The practical application of glass in construction and decoration for domestic purposes is described. Illustrated. F.G.H.

PATENTS

Apparatus for:

Bending or tempering sheets of glass. Pittsburgh Plate Glass Co. Fr. 832,611, Sept. 29, 1938; *Chem. Abs.*, **33**, 2667 (1939).

Drawing pipes from quartz or glass having a high content in silicic acid. Walter Hänlein (Patent-Treuhand-Ges. für elektrische Glühlampen m. b. H.). U. S. 2,155,131, April 18, 1939 (March 8, 1938).

Drawing and severing glass rods or tubing. C. A. Brown and F. B. Van Sickle (General Electric Co.). U. S. 2,157,067, May 2, 1939 (June 21, 1934).

Feeding articles such as lamp bases. British Thomson-Houston Co., Ltd. Brit. 504,246, May 3, 1939 (July 28, 1937).

Manufacturing glass wool bats, etc. D. C. Simpson and T. A. Collins (Owens-Corning Fiberglas Corp.). U. S. 2,154,476, April 18, 1939 (March 12, 1934; renewed May 18, 1937).

Tempering glass objects. André Maurice Thuret. Fr. 832,152, Sept. 22, 1938; *Chem. Abs.*, **33**, 2668 (1939).

Bottle and stopper grinding machine. J. J. Jeffries and H. C. Knoblock. U. S. 2,154,681, April 18, 1939 (May 10, 1938).

Brake-lining material, glass fabric. Olaf Rasmussen (General Motors Corp.). U. S. 2,158,337, May 16, 1939 (Sept. 13, 1937).

Building block. E. E. Slick. U. S. 2,158,089, May 16, 1939 (Jan. 9, 1937).

Closures for jars, etc. Canning Town Glass Works, Ltd., and J. S. Franklin. Brit. 504,303, May 3, 1939 (Oct. 29, 1937).

Compound glass. H. W. Matheson. U. S. 2,155,142, April 18, 1939 (May 29, 1935).

Device for drawing out an endless glass band from the melt. N. V. Hollandsche Mij. voor de Vervaardiging van Glas. Ger. 671,070, Jan. 12, 1939 (June 27, 1936); VI/32*a*. 23.03.—The endless glass band is drawn out continuously from the open surface of a drawing hearth in a vertical position by employing a drawing top projecting with its edges over the glass surface and dipping into the glass melt, a rib lying over the glass surface for defining the drawing line, and two slotlike openings for streaming up of the glass in its base. The slotlike openings of the drawing top lie oblique to the streaming direction of the glass from the melt container, and the opening for the streaming up of the glass in the drawing top on the side toward the melting container is farther removed from the rib of the drawing top than the other glass inlet opening. D.A.B.

Device for removing and changing cracked upper ends of an endless glass band being drawn vertically from the melt. N. V. Hollandsche Mij. voor de Vervaardiging van Glas. Ger. 670,978, Jan. 5, 1939 (May 27, 1936); VI/32*a*. 33.—A device is described for removing cracked upper ends of a continuous glass band in an approximately horizontal plane by means of a swinging frame revolving around a horizontal axis and arranged on the emerging end of the vertical drawing shaft which carries an individual pair of pressure rollers for holding the glass band end which is to be cut. Each roller of this pair is driven positively. A roller path serves for laying aside the broken end of the glass band coming through the frame in an almost horizontal position; the rollers of the roller path are driven with considerably greater speed than the roller of the drawing shaft and of the frame, and therefore attachments are provided which cause the rollers of the frame to move apart and, in so doing, release the cut end of the glass band as soon as it arrives at the roller path for support. D.A.B.

Double-walled vacuum-insulated glass containers. R. Mittelbach. Brit. 504,147, May 3, 1939 (Feb. 16, 1938).

Drawing glass strip. Andrew Jollie (Pittsburgh Plate Glass Co.). U. S. 2,157,759, May 9, 1939 (Jan. 22, 1937; renewed March 14, 1939).

Feeding device for continuously pushing forward a glass width on a grinding device. F. B. Waldron (Pilkington Bros., Ltd.). Ger. 671,303, Jan. 19, 1939 (Jan. 31, 1938); XII/67*a*. 15.—A feeding device consists of a pair of rollers for continuously advancing glass widths on a grinding device by means of tools arranged above and under the glass width. The roller above the feed is provided with ridges on its upper surface which form several openings with the feed roller at the place of contact of the glass width, and one or more jets are arranged in the direction of motion of the glass width in front of the feeding rollers which are provided with the ridges so that they maintain an aqueous layer which is in constant motion with the contact surfaces of the roller with the glass. D.A.B.

Feeding device for glassworking machines. Jakob Dichter. Ger. 671,136, Jan. 12, 1939 (March 11, 1933); VI/32*a*. 27; addition to Ger. 610,853.—The glass tube lengths are brought before a support or holder on the glass-

working machine. The lifting stroke of the movable sliding pusher of the feed machine is so calculated that it pushes the tubes by the ends through a support until the open end of these tubes is connected tightly on the pressure feed of the glassworking machine. D.A.B.

Flexible ceramic objects. FRITZ OBENAUS AND WILHELM REGERBIS (Porzellanfabrik Kahla). Ger. 668,551, Nov. 10, 1938 (May 4, 1937); VI/80*b*. 23.01.—The object, which consists of a number of very thin rods or tubes, is fixed with the ends cemented in a metallic casting or fixed in the casting with metals, *e.g.*, lead. D.A.B.

Forehearth for molten glass. BRITISH HARTFORD-FAIRMONT SYNDICATE, LTD. (Hartford-Empire Co.). Brit. 503,035, April 13, 1939 (Oct. 20, 1937).

Formation of cellular glass. VLASTIMIL STRAKA. Ger. 669,159, Nov. 24, 1938 (Aug. 25, 1937); VI/32*b*. 1.—Ground glass with an admixture of gas-forming substance is heated. Material such as calcium carbonate is used which at the temperature when the glass is plastic, begins to liberate gases in an amount proportional to the increase in temperature. Upon cooling, the glass has closed cells. D.A.B.

Formation of necks on hollow glass objects (flasks). JAKOB DICHTER. Ger. 670,112, Dec. 15, 1938 (Sept. 19, 1936); VI/32*a*. 26.—Necks are produced from glass tubes by means of a die which is inserted into the neck opening of the hollow glass object. D.A.B.

Glass building block. H. L. EASTUS (Owens-Illinois Glass Co.). U. S. 2,156,623, May 2, 1939 (June 29, 1937).

Glass circulating apparatus. H. R. SCHUTZ (Libbey Glass Co.). U. S. 2,154,535, April 18, 1939 (Sept. 16, 1936).

Glass-cutting apparatus. JAMES GREGORY (Pittsburgh Plate Glass Co.). U. S. 2,156,847, May 2, 1939 (Nov. 4, 1937; renewed March 14, 1939). WILLIAM OWEN (Pittsburgh Plate Glass Co.). U. S. 2,156,864, May 2, 1939 (Nov. 4, 1937; renewed March 14, 1939).

Glass fibers. VETROCOKE SOC. ANON. Fr. 832,350, Sept. 26, 1938; *Chem. Abs.*, **33**, 2667 (1939).—Glass fibers or threads suitable for sound or electrical insulation are obtained by extruding molten glass from a furnace through a number of jets in such manner that the fibers collect as a felt or heap in which the fibers are entangled or felted to a high degree. The apparatus comprises means for regulating the number of issuing threads, the temperature, and the rate of flow.

Glassmaking material. H. C. LEE (Society for Savings in the City of Cleveland). U. S. 2,155,721, April 25, 1939 (Aug. 1, 1936).—A glassmaking material comprises silica, soda, and a lime component which is limestone calcined and superficially reacted in the calcining heat with 0.1 to 1% of available boron oxide.

Glass sheets. COMPAGNIE INTERNATIONALE POUR LA FABRICATION MÉCANIQUE DU VERRE (Procédés Libbey-Owens). Fr. 832,298, Sept. 23, 1938; *Chem. Abs.*, **33**, 2667 (1939).—Glass sheets are drawn from a molten mass of glass in continuous manner by means of drawing rollers in a substantially vertical direction without any bending.

Glass sheets. COMPAGNIE INTERNATIONALE POUR LA FABRICATION MÉCANIQUE DU VERRE (Procédés Libbey-Owens). Fr. 832,299, Sept. 23, 1938; *Chem. Abs.*, **33**, 2667 (1939).—Endless glass sheets are drawn from dies or similar devices disposed in a heated drawing chamber the depth of which is less than that of the vessel containing the bulk of the molten glass. Heating devices are arranged underneath the drawing chamber so that the glass is heated at the place where it is converted into sheets.

Glassware foot making machine. J. W. R. HITESHEW. U. S. 2,157,985, May 9, 1939 (Nov. 13, 1936).

Ground-glass joint. H. K. MARTIN (Corning Glass Works). U. S. 2,154,574, April 18, 1939 (May 24, 1938).

Head tongs for glass-blowing machines. JOSEF ERBEN (Vereinigte Lausitzer Glas Werke A.-G.). Ger. 670,111, Dec. 15, 1938 (May 24, 1937); VI/32*a*.1 5. D.A.B.

Induction furnace for heating glass plates of large dimensions and minimum thicknesses. SOC. ASSUREX LE ROI DES VERRES DE SÉCURITÉ MAGNIEN, MONNIER & CIE, G.M.B.H., AND LÉON A. E. PETIT. Ger. 665,534, Sept. 8, 1938 (Jan. 14, 1935); VIII*c*/21*h*. 18.20.—An induction furnace for heating glass plates of large dimensions and minimum thicknesses is described as one having automatic temperature control and whose inner walls consist of superimposed bands of magnetic material running lengthwise. The bands running the length of the furnace lie vertical to the windings of the primary coils and each band is surrounded by a casing or winding of conducting material which is nonmagnetic. D.A.B.

Laminated safety glass. LIBBEY-OWENS-FORD GLASS CO. Brit. 502,905, April 13, 1939 (May 3, 1937).

Laminated safety glass and plastic materials therefor. LIBBEY-OWENS-FORD GLASS CO. Brit. 502,904, April 13, 1939 (Dec. 31, 1936).

Lehr stacker. T. F. PEARSON (Crown Cork & Seal Co., Inc.). U. S. 2,154,992, April 18, 1939 (Feb. 5, 1937).

Lens. WILLY SCHADE (Eastman Kodak Co.). U. S. 2,158,201, May 16, 1939 (Nov. 19, 1937).

Lens system. C. W. FREDERICK AND WILLY SCHADE (Eastman Kodak Co.). U. S. 2,158,178, May 16, 1939 (May 22, 1937). WILLY SCHADE (Eastman Kodak Co.). U. S. 2,158,202, May 16, 1939 (Nov. 19, 1937).

Light-transmitting building construction. LELAND LOGAN. U. S. 2,154,686, April 18, 1939 (March 7, 1936).

Machine for blowing hollow glassware. W. E. EVANS (O'Neill European Machine Co.). Brit. 502,246, March 29, 1939 (June 8, 1937).

Machine for cutting sheet glass. FELICIEN (Felix) GOFFAUX. U. S. 2,158,900, May 16, 1939 (Dec. 31, 1937).

Making laminated safety glass. B. J. DENNISON (Pittsburgh Plate Glass Co.). U. S. 2,156,680, May 2, 1939 (Dec. 4, 1936).

Making lenses. R. W. LUCE (Signal Service Corp.). U. S. 2,157,209, May 9, 1939 (March 22, 1938).

Manufacture of rock wool. W. E. TYLER, P. R. CHAMBERLAIN, AND R. A. LOVELAND (Dewey Portland Cement Co.). U. S. 2,155,107, April 18, 1939 (Nov. 25, 1936).—In a method of making rock wool, a step comprises forming a charge of a mixture of between 10 parts of Portland cement clinkers and 4 parts of siliceous acidic rock material and 10 parts of the clinkers and 30 parts of the rock material by weight, the clinkers and rock having approximately the following composition:

	Clinkers (%)	Rock (%)
SiO_2	21.5	89.8
Al_2O_3	7.1	4.8
Fe_2O_3	3.6	2.9
CaO	66.5	0.4
MgO	1.4	0.3

Means and method for making glassware. LOUIE WOHINC. U. S. 2,156,613, May 2, 1939 (March 17, 1937).

Method and apparatus for drawing glass. W. O. AMSLER (Frazier-Simplex, Inc.). U. S. 2,158,669, May 16, 1939 (May 6, 1935).

Method and apparatus for obtaining tempered glass sheets. E. FERLITO. Brit. 503,649, April 26, 1939 (Dec. 24, 1937).

Multicellular glass and method of manufacture. BERNARD LONG (Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St.-Gobain, Chauny & Cirey). U. S. 2,156,457, May 2, 1939 (June 2, 1936).—A method of manufacturing multicellular glass comprises incorporating in a sodiocalcic glass batch a powder of a reducing metal and at least one metallic oxide having the property of being dissociated under the action of the temperature, fusing the glass batch, and subsequently maintaining the resulting glass material close to its softening temperature to cause the glass material to swell and form a spongelike or multicellular structure.

Photographic objective. C. W. FREDERICK AND G. H. AKLIN (Eastman Kodak Co.). U. S. 2,158,179, May 16, 1939 (May 22, 1937).

Plate glass surfacing table. WILLIAM OWEN (Pittsburgh Plate Glass Co.). U. S. 2,156,699, May 2, 1939 (March 29, 1938).

Polishing block. JAMES GREEN (Pittsburgh Plate Glass Co.). U. S. 2,156,686, May 2, 1939 (Oct. 20, 1937).

Polyvinyl acetal resin plastic materials. LIBBEY-OWENS-FORD GLASS CO. Brit. 502,906, April 13, 1939 (May 14, 1937).

Pouring devices for bottles, etc., for preventing refilling. A. N. GABRIEL. Brit. 503,966, May 3, 1939 (Oct. 22, 1937).

Process and apparatus for separating laminated glass sheets. F. W. HALL (Pittsburgh Plate Glass Co.). U. S. 2,156,688, May 2, 1939 (March 4, 1938).

Producing colored cement-bonded shatterproof layer glass. B. E. GROSSMANN. Ger. 668,550, Nov. 10, 1938 (April 11, 1936); VI/80*b*. 14.02.—A shatterproof glass consists of two sheets of glass; one side of one of these sheets is covered with a mass consisting of artificial resin and sintered filler material containing cellulose, coloring material, and ethereal solvent, dried, and then covered with a second water-soluble mixture of artificial resin containing HCl as hardening agent. A side of the second sheet of glass is similarly treated with the aqueous resin mixture. Both are dried and put together. D.A.B.

Producing colored glasses, glazes, and enamels. E. I. DU PONT DE NEMOURS & CO., INC. Ger. 668,860, Nov. 17, 1938 (July 17, 1935); VI/32*b*. 2.—Colored glasses, glazes, and enamels are produced by using a coloring admixture containing cadmium sulfide and selenium. In addition to the CdS, cadmium in the elementary state is added to the mixture of raw materials in which all the coloring admixture, based on the melt, amounts to 1 to 2%. D.A.B.

Producing corrugated wire glass. FERDINAND KINON. Ger. 668,261, Nov. 3, 1938 (Oct. 6, 1937); VI/32*a*. 22. Addition to Ger. 639,736, Dec. 11, 1936.—The sheets of glass are taken to the corrugating press, and corrugation ridges are produced parallel to the wire in the glass. D.A.B.

Producing glasses with silky luster by separation of crystals. OSKAR REDLHAMMER (Eduard Redlhammer und Söhne). Ger. 671,291, Jan. 19, 1939 (March 25, 1937); VI/32*b*. 1.—An ordinary glass with a specific weight under 3.3, to which the usual opacifiers are added, is subjected to a devitrifying process outside of the fused mass in a known manner. The product obtained, which has a silky luster, is softened again, and in this state it is formed as desired. D.A.B.

Producing glass filaments from the molten mass. OSCAR GOSSLER GLASGESPINST-FABRIK G.M.B.H. Ger. 669,283, Dec. 1, 1938 (Nov. 21, 1936); VI/32*a*. 25.—Nozzles or jets are arranged in the shaft oven so as to turn around its vertical axis on revolving rings at the bottom of the furnace parallel with its axis, and the heated gases are introduced into the oven in the direction of the shaft so that the jet or nozzle rings are maintained at approximately the same temperature. D.A.B.

Producing sponge glass. VLASTIMIL STRAKA, BERNHARD WEINER, AND JINDRICH KLOUBEK. Ger. 668,592, Nov. 17, 1938 (March 12, 1937); VI/32*b*. 1.—Sponge glass is produced from ground glass which is mixed with materials vaporizing or gasifying at the temperature of the viscous glass but not decomposing; upon cooling of the glass, these materials go back into their original state and leave an evacuated cavity or space in the glass mass to produce the sponge glass. D.A.B.

Producing thread or twine from glass fibers. CLAUS SIEGFRIED (A.-G. der Gerresheimer Glashüttenwerke vorm. Ferd. Heye). Ger. 671,055, Jan. 12, 1939 (March 18, 1937); VI/32*a*. 25.—A method for producing thread, etc., from glass fibers is described. The glass fibers, upon their production, are led to a mobile surface such as a revolving drum, rotating table, etc., on which the fibers are joined or combined, with the appearance of a glass-felt covering; they are then drawn off in the form of a loose band through a winding device. D.A.B.

Production of toughened glass. H. ARON (F. Ferré & Cie.). Brit. 504,191, May 3, 1939 (Oct. 20, 1937).

Refractory glasses. GENERAL ELECTRIC CO., LTD. (Patent Treuhand-Ges. für elektrische Glühlampen m.b.H.). Brit. 504,062, May 3, 1939 (Feb. 10, 1938).

Regulating the tarnishing or attack of selenium-ruby glasses. HANS LÖFFLER (Deutsche Gold- und Silber-Scheideanstalt vorm. Roessler). Ger. 668,593, Nov. 17, 1938 (Dec. 18, 1936); VI/32*b*. 4.—A method is described for regulating the tarnishing or attack of selenium-ruby glasses which contain cadmium selenide or compounds containing this substance. Sulfur is added to the glass mixture in the form of alkali sulfides, alkali thiocyanates, or zinc thiocyanate to accelerate the tarnishing or attack, in the form of zinc sulfide, arsenic sulfide, or iron sulfide to hinder the action, or in the form of earth-alkali sulfides, tin sulfide, or antimony sulfide to produce intermediate action. D.A.B.

Reinforced glass. SOC. DES USINES CHIMIQUES RHÔNE-POULENC (Emile Clement Cottet, inventor). Fr. 832,424, Sept. 27, 1938; *Chem. Abs.*, **33**, 2668 (1939).—Glass is reinforced by sheets of a polyvinyl resin of the acetal or partial ester type. A sheet of the resin is softened by immersion in a liquid containing a plasticizer, *e.g.*, benzyl alcohol, ethylene glycol monoacetate, glycerol formal, or the lactone of hydroxybutyric acid, and while still in the liquid is placed between two glass sheets. The three sheets are pressed together, removed from the liquid, and placed in an autoclave containing a gas under pressure and at elevated temperature.

Sealing ampoules, etc. JAKOB DICHTER. Ger. 671,056, Jan. 12, 1939 (May 9, 1935); VI/32*a*. 27; addition to Ger. 654,167.—In a machine for sealing ampoules, etc., the ampoules revolve in an endless series, and during the sealing the ampoules and burners are rotated oppositely. For each of the ampoule holders, one or more burners revolving with the ampoule around the axis of the holder are arranged in such a manner that the burner's flame is directed upon the place of the ampoule which is to be sealed. D.A.B.

Spinning glass. C. G. HARFORD AND EARL STAFFORD (Arthur D. Little, Inc.). U. S. 2,156,982, May 2, 1939 (March 9, 1934; renewed May 12, 1938).

Telescope objective. ALBERT KÖNIG (Carl Zeiss). U. S. 2,158,507, May 16, 1939 (June 12, 1937).

Tempered glass objects. CORNING GLASS WORKS. Fr. 831,246, Aug. 26, 1938; *Chem. Abs.*, **33**, 2668 (1939).—Tempering is effected by means of liquids, the cooling powers, H, of which lie between the values obtained from the two formulas: $\log (H \times 10^6) = 4 + 0.003\ T$ and $\log (H \times 10^6) = 2.5 + 0.003\ T$, where T is the temperature of the cooling bath. H is defined by the formula $H = K^3 \cdot P^2 B \cdot C/V$, where K = thermal conductivity of the liquid, P = specific gravity, B = coefficient of expansion, C = specific heat at constant pressure, and V = viscosity. The liquid may be 1,2,4-trichlorobenzene, diphenyl oxide, or a chlorinated resin.

Tempering glass objects. ANDRÉ MAURICE THURET. Fr. 831,353, Sept. 1, 1938; *Chem. Abs.*, **33**, 2668 (1939).—A glass object, immediately after removal from the mold, is treated so as to obtain an equalization of the temperatures in its mass between the exterior surface and the internal layers at a temperature in the region of the softening point. The object is then subjected to a rapid cooling. To obtain equalization of temperature, the glass object is placed in a heat-insulated enclosure with reflecting walls or in an enclosure which is heated to a temperature in the region of the softening point of the glass.

Treating hollow glass articles. O. G. BURCH (Owens-Illinois Glass Co.). U. S. 2,154,490, April 18, 1939 (Dec. 9, 1936).

Treating laminated glass. R. G. WHITTEMORE (Pittsburgh Plate Glass Co.). U. S. 2,156,714, May 2, 1939 (March 26, 1937).

Treating mineral fibrous substances, such as glass wool, slag wool, etc. C. HANNEN. Brit. 503,979, May 3, 1939 (Dec. 28, 1936).

Unbreakable lenses. ERNEST G. LLOYD. Fr. 831,404, Sept. 2, 1938; *Chem. Abs.*, **33**, 2627 (1939).—Lenses are made of transparent plastic material, *e.g.*, a polymer of acrylic acid, by placing the plastic material between matrices of the desired inverse shape and molding by means of heat and pressure.

Union between ceramic parts and metal. GÜNTHER DOBKE (Allgemeine Elektricitäts-Ges.). Ger. 668,623, Nov. 17, 1938 (June 29, 1937); VI/80*b*. 23.01.—A vacuum resistant union between parts of ceramic work material and metal is brought about by the use of a solder. The surface of the metal to which the solder is to adhere is coated with a protective coating which, as well as the ceramic part, is wetted by the solder in the ordinary manner. D.A.B.

Structural Clay Products

Base exchange—its significance in ceramics and relation to workability of clays. ROBERT P. GRAHAM. *Ceram. Age*, **32** [3] 70–71 (1938); see *Jour. Amer. Ceram. Soc.*, **21** [5] 176–83 (1938). F.G.H.

Effect of atmospheric exposure on the properties of unfired clay bodies. J. O. EVERHART AND R. RUSSELL, JR. *Jour. Amer. Ceram. Soc.*, **22** [6] 200–203 (1939).

Importance of carbonization in the production of silicate (sand-lime) brick. P. N. GRIGOR'EV. *Stroitel. Materialy*, **1938**, No. 4, pp. 45–48.—The mechanical strength of the brick immediately after autoclaving is sufficient for practical purposes and is determined by the compounds formed during the process. The natural carbonization is limited to surface layers of the brick and influences the increase of mechanical strength of air-stored brick. Artificial carbonization during autoclaving considerably lowers the mechanical strength. P.B. & E.S.

BOOK

Papers of the Central Laboratory of Building Materials. Vol. II. Edited by A. I. KRAMARENKO. People's Commissariat of Local Industry of the Ukrainian S.S.R., Kiev, 1938. 168 pp. Price 3 R. Chapters are included on the dry pressing of brick and clinker, the increase of output of mechanical and thermal plant equipment, facing materials, the production of white Portland cement, and the investigation of Ukrainian clays and sands for producing brick and tile. P.B. & E.S.

PATENTS

Manufacture of brick, etc. W. CREIGHTON AND WOODHAM BRICK CO., LTD. Brit. 502,185, March 29, 1939 (Sept. 16, 1937).

Method of and brick for building walls, etc. W. S. GRICE. Brit. 503,785, April 26, 1939 (Oct. 13, 1937).

Wall construction. C. R. EMERY. U. S. 2,158,412, May 16, 1939 (March 4, 1938).

Refractories

Beryllium oxide. H. E. WHITE AND R. M. SHREMP. *Jour. Amer. Ceram. Soc.*, **22** [6] 185–89 (1939).

Chromium ores for refractories. ANON. *Jour. Four. Élec.*, **48** [1] 25 (1939).—Chromium ores used for refractories contain too much serpentine; 0.333% of magnesia is necessary to neutralize 1% of silica. Tests have been made in England with ores of different origin, with different additions, and with different grain sizes. Rhodesian ore showed the best results after the addition of the theoretical amount of calcined Greek magnesite. Brick with an addition of lime showed no improvement over brick made of unmixed ore. Barium sulfate improved Rhodesian and Greek ores but not Turkish ores. For high temperatures, the best grain sizes were obtained by mixing Turkish ores (45 coarse, 10 medium, 45% fine) and Greek ores (either 22 coarse, 24 medium I, 16 medium II, 38% fine or 7 coarse, 50 medium I, 35 medium II, 8% fine). The Greek ores are mixed in both cases with 5% barium sulfate. Further tests were made concerning porosity, density, and slag resistance. Tests are now being made in a large furnace with compressed brick, with and without addition of barium sulfate. In France, brick pressed before firing have been in use several years with good success. One standard product is made from Caledonian ore. J.M.N.

Control of expansion in modern coke ovens. C. BERTHELOT. *Coal Carbonisation*, **3**, 153–55 (1937).—For economy the substructure of coke ovens is made of semisilica brick having a thermal expansion of about half that of silica brick used in the superstructure of the ovens. Consequently, the pulling effect of the silica brick expansion causes joints to open in the substructure. The actual expansion of the superstructure was $7^1/_2$ in. and that of the substructure was $3^1/_2$ in., measured from outside bench marks by surveying methods. The use of tie rods to exert a controlled pressure on the silica and semisilica structures independently in heating up is described. L.R.B.

Creep of refractory materials at high temperatures and its bearing on the performance of glasshouse pots. J. H. PARTRIDGE. *Chem. Age* [London], **40**, 236 (1939).—The extension under tension (creep) at various temperatures is more rapid with aluminous fire clays than with siliceous clays. A mixture of siliceous clay and 20% aluminous clay, however, does not creep and is more stable to corrosion. Creep is due to extension resulting from the recrystallization of silica from the glassy matrix and to extension due to the creep of the glassy matrix. Impurities seriously lower the temperature at which failure occurs. P. questions the practical value of highly refractory glasshouse pots in which diffusion of the glass constituents may cause serious weakening. A.B.S.

Determining the life of saggers. ANON. *Keram. Rundschau*, **45** [43] 496–97 (1937).—To determine the duration of saggers, it is necessary to make tests at different places in the kilns. In one instance, saggers showed good resistance except in the vicinity of ports. Resistance to thermal shock was overcome by changing the clay so as to obtain a more porous material. F.E.V.

Fire-clay brick for use in iron and steel works. J. H. CHESTERS AND T. W. HOWIE. *Trans. Brit. Ceram. Soc.*, **38** [2] 131–51 (1939).—Although aluminous brick are increasingly used for lining blast furnaces, more siliceous materials have given good service in the past and are therefore included in tentative specifications. Fine grinding of the batch results in a great increase in cold crushing strength and a marked decrease in the permeability of blast-furnace brick. Slag tests suggest that the 40% alumina fire-clay brick is more resistant to a slag of the composition SiO_2 30.8, Al_2O_3 14.6, CaO 46.2, and BaO 3.5% than brick of the 35% Al_2O_3 variety. Blast-furnace stove dust, which is a complex mixture of iron oxide, carbon, lime, etc., also attacks high-alumina brick less than the ordinary medium-alumina variety. The properties of a number of runner brick, rod covers, nozzles, stoppers, and mold top brick are summarized. Certain trends, such as the change to more aluminous materials for casting hot metal or high Mn steels, are noted. Thermal shock tests suggest that deaired products car possess a high spalling resistance in spite of their dense texture. An increase in the firing temperature of a particular rod cover (sleeve) from 1000° to 1100°C resulted in a decrease in spalling resistance index from 15 to 6 reversals, together with a drop in the porosity and permeability. X-ray examination showed that the amount of mullite present had increased, while the gamma alumina present in the 1000°C sample had disappeared. Nozzles and stoppers are made from very refractory clays and are usually extremely dense. Mold top brick and sleeves vary considerably in their properties according to origin. R.A.H.

Fire clays and alumina refractories of the Witwatersrand area and its environs. V. L. BOSAZZA. *Trans. Brit. Ceram. Soc.*, **38** [2] 123–30 (1939).—In connection with an investigation of the clay deposits of the Witwatersrand

(S. Africa) area, B. studied the finished ware and its durability in service. R.A.H.

Heat insulation of coke-oven tops. ANON. *Coal Carbonisation*, **3**, 67–69 (1937).—The effect of insulating the coke-oven roof is discussed in the light of experience and as predicted by heat-transference calculations which are given in detail. The introduction of 6 in. of insulating brick in a 36-in. top reduces the heat loss 174 B.t.u./sq. ft./hr. The hot-face temperature rises (contrary to general assumption) by about 90°F and raises the temperature of the coke oven gas by about 80°F, requiring 160 B.t.u./sq. ft. of heating surface per hour. Other sources of loss, *e.g.*, through the covers on the charging holes and inspection flues, in the waste flue gases, and in discharging, are negligible. Overheating of the crown must be prevented. By suitable design and operation so that the top is just hot enough if insulation is used, fuel economy is possible. L.R.B.

Longer life for furnace walls. ANON. *Power*, **81** [10] 622–23 (1937).—Factors involved in the maintenance of boiler-furnace refractories are briefly discussed. F.G.H.

New door frame for open hearth. BLAW-KNOX CO. *Steel*, **102** [12] 55 (1938).—A design of a tapered water cooled door frame for open-hearth furnaces is explained and illustrated. The wider top opening is desirable when the materials being charged extend above and beyond the top of the charging box. It has a longer life and offers greater protection to the operators. H.E.S.

Obtaining hydraulically hardening refractory dolomite cements. S. D. OKOROKOV AND P. I. NOVIKOV. *Tsement*, **5** [11] 27–35 (1938).—Study of the ceramic properties of refractory dolomite cements shows that these cements and materials made from them have high refractoriness, high temperature of deformation under load, and high resistivity to open-hearth slags and are sufficiently resistant to spalling (air cooling). They can be used for linings of cement kilns and metallurgical furnaces. P.B. & E.S.

Production of aluminum. A. CLERGEOT. *Electricité*, **23** [52] 1–4; [53] 49–53 (1939).—C. describes different processes and the preparation of materials and deals with the regular smelting and refining processes. Photographs and sketches of several furnaces are shown. The use of refractories for the refining furnace is of interest. The Compagnie Alais, Froges, et Camargue uses a furnace with carbon blocks in the bottom and magnesite brick in the walls, both surrounded by refractory brick. Its shell is brazed. The purity of the metal is 99.99 to 99.995% Al. J.M.N.

Production of chromite and magnesite refractories in Italy. L. POMPEI. *Corriere Ceram.*, **20** [3] 85–89 (1939).—The Italian sources of chromite are on the island of Rodi and those of magnesite are at Castiglioncello (Pisa), an impure form, and Querceto (Elsa valley), which is much purer. Analyses are given. The manufacture (by pressing at 1000 kg./cm.²) and use are described. See *Ceram. Abs.*, **17** [4] 143 (1938). L.R.B.

Properties of semisilica brick. G. BICKLEY REMMEY. *Jour. Amer. Ceram. Soc.*, **22** [6] 193–99 (1939).

Refractories and the coke oven. ANON. *Coal Carbonisation*, **4**, 94–96 (1938).—The use of "straight" silica brick for coke ovens is now standard practice. A reduced permeability is more important than a specific gravity of 2.35 or less and can be attained by attention to grading and semidry pressing. At the ends near the doors a "soft-fired" silica should be used as it is more resistant to spalling. In the regenerator, 35 to 37% alumina brick are better than 33 to 35% alumina brick, except for the top few feet which should be of semisilica brick. Silica contents of 90 to 94% are now advocated for this purpose. Cost may prevent the complete replacement of fire clay by silica in the regenerators. A siliceous cast-monolithic door lining is superior to jointed fire-clay brick; insulating concrete of adequate refractoriness offers the advantages of lightness and heat conservation, with less difficulty in avoiding "black ends" (low-temperature coke produced by insufficient heat available for coking near the doors). Oven repairing is done by (1) hot patching with refractory cements applied with a paddle, (2) cooling and rebuilding, or (3) spraying cement directly onto the hot wall. The cement for this last purpose should be of high refractoriness, vitrifiable at working temperature, free from shrinkage and flaking on drying, and capable of remaining in permanent suspension in water. L.R.B.

Refractories for electric furnaces. MAURICE DÉRIBÉRÉ. *Electricité*, **22** [49] 311–16; [51] 393–98 (1938).—D. reviews the properties and applications of modern refractories and gives equilibrium diagrams (binary and ternary) and tables showing compositions, densities, porosities, melting points, load-test properties, and moduli of rupture. He deals with silica, alumina, magnesite, lime (and mixtures of these), carbon (graphite and amorphous), silicon carbide and other carbides, chrome, zircon, beryl, and thoric oxide. J.M.N.

Refractories in Lancashire boiler practice. C. S. DARLING. *Steam Engr.*, **8**, 137–39 (1939).—D. points out that the grate or stoker of a boiler furnace is merely a gasification apparatus, the greater part of the heat for raising steam being obtained above the fuel bed. The combustion of gases above the fuel bed is complete, and smoke emission is prevented above 1500°F. D. suggests, therefore, that the thermal efficiency of a hand-fired coal-fueled Lancashire boiler can be increased by raising the firebox temperature by means of a plastic refractory (rather than by ordinary arch brick) in good contact with the crown along its entire length. The gases do not come in contact with the cold crown of the firebox until combustion is complete. Ebullition conditions are improved and there is less risk of priming. Tube or crown collapse is much less probable. A further increase in efficiency is possible by avoiding high heat-capacity brick gas passages, especially in intermittently fired boilers. L.R.B.

Resistance of refractories to tension at high temperatures. L. LONGCHAMBON AND LIU-PING-KUN. *Arts du Feu*, **1** [3] 81–84 (1938).—The test is described in detail. The diagram shows a slight extension and then a sharp contraction due to chemical interaction, a short horizontal line, a rapidly increasing extension due to viscosity, and finally breakage. This method was used to determine the effect of the size of quartz grains and the lime content on refractories. Granulometry of quartz does not modify the temperature at which chemical action begins. The contraction increases enormously with fineness of grains and later decreases quickly with augmenting fineness. Very fine grains lengthen the horizontal line (strength of body very high); the viscosity increases at once and the rupture is like that of an alkaline glass. High lime content reduces strength and chemical contraction. This difficult test is intended only for laboratories. F.E.V.

Resistance of refractory products to high temperatures. D. PETIT. *Arts du Feu*, **1** [3] 85–92 (1938).—The usual methods are described. A new method devised by P. consists in plotting the loads against temperatures for a given shrinkage. These curves converge at the melting point; they give useful information for practical problems. F.E.V.

Results of application of streamlined form of brick in regenerators of steel-mill furnaces. ROMAN DAWIDOWSKI. *Hutnik*, **10** [10] 507–15 (1938); *Metals & Alloys*, **10** [4] MA 212 (1939).—Results are given of an inspection of a regenerator in which the checkerwork is made up of brick of a newly developed streamlined shape. A saving of 24.5% fuel with an increase in the life span of the brickwork, permitting a corresponding rise of the amount of steel produced per ton checkerwork from 110.2 to 203.2 tons, is made possible by this innovation. 15 references.

Service of magnesite powder in an arc furnace. V. M. ZAMORUEV. *Metallurg*, **14**, 46–55 (March, 1939).—Frequent defects in the arc furnaces at the Kirov plant interfered with the smelting process and made it impossible to produce high-quality steel. The defects were due to the insufficient stability of the bottom and furnace magnesite slopes. This accounted for large amounts of magnesia found in the slags. The quality of the various grades of magnesite used was tested. The quality of the magnesite

is determined by its chemical composition, specific gravity, grain size, and porosity. Results show that good magnesite powder should conform to the following specifications: specific gravity not less than 3.5, porosity 35 to 40%, and grain size (*a*) less than 1% dust, (*b*) not over 30% of the grains under 0.2 mm., (*c*) 20 to 30% of grains over 4.0 mm., and (*d*) no residue on a 15 mm. sieve. The magnesite should contain 90 to 91% MgO and not over 2.6 CaO, 3.8 SiO_2, 1.0 Al_2O_3, and 2.0 to 3.0% Fe_2O_3. Samples were taken from the furnace bottom and analyzed. The composition varied with the stability of the material. The most stable sample had a composition of 60.28 MgO, 20.08 CaO, 15.58 SiO_2, 1.12 Al_2O_3, 2.60% FeO, and traces of MnO; it consisted chiefly of forsterite with small grains of periclase distributed equally among the relatively large forsterite grains. Small amounts of glass and melilite were also present. B.Z.K.

Silica brick. R. LEDUC. *Rev. Matériaux Construction Trav. Publics*, No. 348, pp. 109–11B (1938).—L. describes the composition and manufacture. The rôle of catalyzers (lime, iron oxide, and phosphorite) is emphasized. The different transformation points must be considered in making the firing schedule. The different types of raw materials must be tested in each case. F.E.V.

Significance of ferrous and ferric oxides in the formation of a magnesite with high or low iron concentration. T. SCHAUER. *Sprechsaal*, **71** [51] 629–30 (1938).—An explanation of the cause of the diversity of the two kinds of technically important natural magnesite (coarse crystalline with high iron content and the fine crystalline low in iron) was attempted on the basis of solubility tests and geological petrographical examinations. Important conclusions for the technique of the refractory industry are as follows: (1) The iron contained in natural magnesite is present mostly as siderite in the ferrous form. Sintering decomposes the ($FeCO_3$) mainly into Fe_3O_4 and FeO, *i.e.*, into strongly magnetizing iron oxide, which can be used for the magnetic purification of sinter magnesite containing iron. (2) For this reason an addition of ferric oxide (brown iron ore) in the production of sinter magnesite containing iron from fine crystalline natural magnesite will never give the desired result without iron and magnesia materials. Ferric oxide does not easily transform into Fe_3O_4 when heated and is usually present in the hexagonal crystal form which more or less disturbs the cubic stability of periclase (MgO) so that no compact sinter block can be produced from it. The structure remains incompact, and sinter magnesite block made in this way have a brick-red appearance instead of the desired brown-red color. The iron must therefore be introduced in the ferrous form which can best assume the cubic crystal form of Fe_3O_4 when fired and which least disturbs the cubic periclase structure, producing a compactly sintered block. This is the case in natural crystalline magnesite with a high iron content, since the ferric oxide has a different solubility. The FeO content instead of the Fe_2O_3 must be better indicated in the chemical analysis results. M.V.C.

Silicon carbide and corundum. SCHAEFER. *Sprechsaal*, **71** [52] 637 (1938).—Silicon carbide and corundum are often confused because of their similar properties and uses as refractory products, emery, and abrasives. Silicon carbide is especially suitable for muffles and "channel" furnaces. Corundum block are very compact and have a high chemical resistance to all slags. M.V.C.

Special problems concerning the application of refractories in electric arc furnaces. MAURICE DÉRIBÉRÉ. *Electricité*, **23** [53] 62–64 (1939).—D. gives data on insulating materials used in connection with refractories, dilatation diagrams and thermal expansion curves of standard brands, and tables on the behavior of these materials in the presence of basic and acid slags, under oxidizing and reducing conditions, and in the presence of different molten metals. J.M.N.

Torsion properties of itakolumite (flexible Brazilian sandstone), Crummendorf quartz-schist, and some sandstones. K. ENDELL AND F. ANGELERI. *Ber. Deut. Keram. Ges.*, **19** [9] 359–66 (1938).—The spalling resistance of refractory materials depends to a certain extent on the degree of internal mobility (elastic distortion and plastic deformation) they possess. Apparatus for measuring this property was described in a previous paper ("Elastic—," *Ceram. Abs.*, **12** [8] 301 (1933)). This apparatus was used to compare the distortability of Brazilian sandstone (itakolumite), Crummendorf quartz-schist, and other sandstones. The unusually dense itakolumite showed the greatest permanent elastic distortability (six times that of silica brick); Crummendorf quartz-schist, parallel to the grain, had a distortability four times that of silica brick. E.J.V.

Uniform heating of coke ovens. ANON. *Coal Carbonisation*, **3**, 83–85 (1937).—Calculations show that 18 in. of brickwork, including 3 in. of backup insulation for doors and flues at the ends, reduces the heat losses so much that a somewhat larger gas supply to the two end flues is all that is necessary for uniform heating in the coking of the coal. L.B.R.

Utilization of Indian magnesite as a refractory material. D. SWARUP. *Indian Ceramics*, **1** [2] 39–40 (1938).—Indian magnesite is very pure and can not be sintered easily and cheaply. Iron oxide is mixed to lower its sintering temperature to 1650°C and to convert the amorphous magnesite to periclase. Iron oxide can be added in three forms: (1) iron ore, (2) soluble iron salt, or (3) slurry of iron with water. Hematite ore in amount of 2.5% is very satisfactory. Indian magnesite fired at 1650°C shows a structure similar to that of Austrian magnesite. When dead-burned it analyzes SiO_2 5.4 to 3.46%, Fe_2O_3 8.0 to 7.3%, Al_2O_3 1.92 to 4.31%, CaO 3.05 to 3.65%, MgO 80.20 to 81.68%, loss on ignition 0.42 to 0.14%, and porosity 16.4 to 20.4%. The addition of silica lowers the refractoriness of magnesite but not that of iron oxide (up to 5% maximum). The employment of one stage of firing in the manufacture of magnesite effects a considerable saving. The method consists in pressing the brick after preliminary dead-burning at a pressure of about 10,000 lb./sq. in. This reduces the void space between the magnesite grains. The interfitting of grains is developed by the proper gradation of the sizes of the individual magnesite particles, and a colloidal coating for the magnesite grains is prepared which acts as a lubricant between the particles. The uses of magnesite brick are listed. A.P.S.

PATENTS

Alumina. DYCKERHOFF PORTLAND - ZEMENTWERKE A.-G. Fr. 832,801, Oct. 4, 1938; *Chem. Abs.*, **33**, 2660 (1939).—In making pure Al_2O_3 from aluminous primary materials, such as bauxite, kaolin, and clay, which are transformed to alkaline-earth aluminates in an appropriate manner, the aqueous solution obtained by leaching the alkaline-earth aluminates is treated with CO_2 under increased pressure to precipitate pure Al_2O_3. The solutions used have a concentration below the saturation point.

Basic refractory substances. E. J. LAVINO & Co. Fr. 832,376, Sept. 26, 1938; *Chem. Abs.*, **33**, 2669 (1939).—Refractories and brick and other articles made thereof comprise a product obtained by a thermal reaction which contains Ca aluminate, monticellite (if desired, also a Ca orthosilicate), and periclase. A primary substance having a basis of lime, magnesia, and silica is mixed with silica and alumina in sufficient quantity to form Ca aluminate and monticellite and, if desired, Ca orthosilicate, with the lime present, and the mixture is heated to effect the desired reaction. Ca orthosilicate may be stabilized by adding a phosphate to the mixture. The mixture may be calcined in a furnace to obtain a clinker which is then broken up and converted into brick.

Blast-furnace construction. S. L. MAMULA. U. S. 2,158,943, May 16, 1939 (Sept. 14, 1937).

Furnace construction. J. O. GRIGGS AND B. H. LEEKS. U. S. 2,155,418, April 25, 1939 (Sept. 22, 1936).—In an open-hearth furnace having a bottom, front and back walls, ends, and a roof, a semicylindrical trough at the top of one of the walls, a roof section engaging the top of the wall and including a metallic frame having flanged edges, a refractory lining held by the frame, and one of the edges located at the wall-engaging portion of the roof section being bent

to form a cylindrical portion complementary to the trough, interfitting therewith and adapted to rotate therein to form a pivotal mounting for the roof section.

Furnace roof. R. P. Heuer. U. S. 2,155,165, April 18, 1939 (May 28, 1937).

Furnace-roof construction. H. A. Morlock. U. S. 2,158,759, May 16, 1939 (Sept. 21, 1937).

High-temperature refractory. J. D. Morgan and R. E. Lowe (Power Patents Co.). U. S. 2,158,035, May 9, 1939 (June 27, 1936).—A method of making a refractory composition suitable for shaping and heat-hardening comprises mixing about 40 parts by weight of milled grain zircon with water to a fluid consistency, adding about 60 parts by weight of ground ferrosilicon, digesting the mixture while in a fluid consistency state for a long period of time at an elevated temperature with about 6 parts by weight of phosphoric acid, and then drying and heat-hardening the digested mixture.

Magnesian refractories. E. J. Lavino & Co. Fr. 832,283, Sept. 23, 1938; *Chem. Abs.*, **33**, 2669 (1939).—A mixture of a granular crystallized magnesian substance and fine silica is subjected to heating at a temperature sufficient to effect a reaction such that grains of periclase coated with forsterite are obtained. Magnesia may be present in the product in the form of a grog bound by forsterite, in all parts of which monticellite is dispersed.

Molding ceramic materials. Michel Alexandre Lacoste. Fr. 832,155, Sept. 22, 1938; *Chem. Abs.*, **33**, 2669 (1939).—To avoid sticking of the soft ceramic paste to the metallic mold, the latter is lined with paper. The paper is destroyed during the firing process.

Preventing or lowering the disintegration of refractory brick at high temperatures by gases. Kohle- und Eisenforschung G.m.b.H. (Fritz Hartmann, inventor). Ger. 659,722, April 14, 1938 (July 27, 1931); VI/80*b*. 12.10.—A method is described for preventing or minimizing the disintegration occurring at high temperature when carbon-free refractory brick containing iron oxide is in contact with gases such as CO, methane, higher homologs of methane, etc. The fireproof brick or masses are treated with any amount of materials counteracting the decomposing characteristics of the iron. Materials such as boric acid, organic salts of boric acid, lead, nickel, chromium, magnesium, manganese, aluminum, arsenic, zinc, and cadmium as metals, oxides, inorganic or organic compounds, and alkali and ammonium phosphates are used in quantities under 1% separately or in combinations. D.A.B.

Producing ceramic-bonded products from granular charge. Deutsche Norton-G.m.b.H. Ger. 669,131, Nov. 24, 1938 (Jan. 29, 1935); VI/80*b*. 18.02.—Particles corresponding to the particles in the sintered material and the binding agent are mixed with each other and water is then added; gas is introduced into the mass, distributed, and held fast. The introduction and dispersion of the gas bubbles are continued until a test of the aqueous mixture shows a predetermined specific weight, which will result in a definite specific weight of the sintered mass corresponding to the desired spacing of the granular particles, binding agent, and pores. D.A.B.

Producing ceramic cast objects and coverings. Wolfgang Rohde (Julius Pintsch Kom.-Ges.). Ger. 670,231, Dec. 22, 1938 (Jan. 4, 1937); VI/80*b*. 8.16.—A method is described for producing cast ceramic objects, especially for the building of discharge pipes, from nonplastic oxides of aluminum, chromium, beryllium, or magnesium, or a mixture of these oxides, which are transformed into the plastic or pastelike state by a binding material, dried (after casting), and then fired. An aluminum formate solution is employed as the binding agent. D.A.B.

Producing pure alumina. R. Englert & F. Becker Chemische Fabrik and "Galina" Finanz-A.-G. (Anton Michels, inventor). Ger. 669,266, Dec. 1, 1938 (Oct. 18, 1934); IV*b*/12*m*. 6. Addition to Ger. 661,174 (*Ceram. Abs.*, **17** [11] 358 (1938)).—The solution of aluminum disulfite and sodium disulfite resulting after the separation of the silicon dioxide is changed with lime to calcium sulfite and sodium aluminate, whereupon the alumina is obtained by the general method from the sodium aluminate. D.A.B.

Producing pure alumina and raw calcium sulfate from alunite. Nihon Denki Kogyo Kabushiki Kaisha. Ger. 670,196, Dec. 22, 1938 (June 4, 1935); IV*b*/12*m*. 5.—Uncalcined pulverized alunite is heated with caustic potash (KOH) whose amount depends on the content of sulfate bound to the aluminum and the alumina content; the KOH is added in the form of a 20 to 50% solution, and the mixture is heated at a temperature of 100° to 150°C. The calcium sulfate together with impurities is crystallized out by cooling. Pure alumina is precipitated, by stirring, from the calcium-aluminate solution which has been filtered from the crystallized $CaSO_4$. D.A.B.

Producing siliceous products. Max Hauser. Ger. 668,549, Nov. 10, 1938 (May 2, 1936); VI/80*b*. 8.21.—A method for producing articles comprises casting and firing masses containing clay, metallic silicon, silicides, or silicon alloys and a fluxing agent. Silicon dioxide in the noncrystalline state or an aluminum silicate rich in silicic acid, such as agalmatolite or fuller's earth, is added which, upon firing of the masses, splits off amorphous SiO_2. D.A.B.

Refractory brick construction. J. B. Tracy (General Refractories Co.). U. S. 2,155,026, April 18, 1939 (Aug. 25, 1937).—For use with a liquid fuel burner and a domestic boiler of the vertical type.

Refractory material. A. F. Greaves-Walker and R. L. Stone (Feldspathic Research Corp.). U. S. 2,155,858, April 25, 1939 (March 18, 1937).—An unfired shaped refractory product includes comminuted olivine, up to 12% of comminuted dolomite initially having a calcium carbonate content of not more than 40%, previously calcined in admixture with comminuted olivine, and silicate of soda in an amount up to approximately 6% (anhydrous basis), the components being compressed together to shape in a moistened state, dried, and adapted for use as a furnace lining without previously being fired, the total amount of olivine being in amount at least several times the sum of all other components of the product.

Refractory materials. E. J. Lavino & Co. Fr. 832,239, Sept. 23, 1938; *Chem. Abs.*, **33**, 2669 (1939).—Mixtures of substances containing CaO, MgO, and SiO_2, *e.g.*, a mixture of dolomite and silica, are heated so as to produce a refractory material in which the Ca is present in the form of orthosilicate, monticellite, or periclase. The Ca orthosilicate may be stabilized by adding a small proportion of a phosphate to the initial material.

Refractory and method of making. Matthew Schon and H. C. Be Ment (Crown Cork & Seal Co., Inc.). U. S. 2,156,608, May 2, 1939 (March 25, 1937).—A refractory lining comprises superposed layers of fused and hardened refractory material fused together, each layer increasing in fusing point from the base of the lining to the surface thereof.

Refractory molding mass. Fried. Krupp A.-G. Fr. 830,350, July 27, 1938; *Chem. Abs.*, **33**, 2669 (1939).—For the production of molded articles made of alloys fusing at temperatures greater than 1100°, the molds are made of material consisting wholly or for the most part of silica (sand) agglomerated with a binder, such as water glass, containing silicic acid. The mold material also contains an addition of a substance capable of precipitating the silicic acid in the binder; this enables the thermal expansion of the mold to take place at a temperature considerably less than 1200° to 1300°. CaO, or other oxide or hydroxide of a metal or metalloid capable of precipitating silicic acid, may be used as the addition.

Refractory products. Rheinische Chamotte- und Dinas-Werke. Fr. 831,456, Sept. 5, 1938; *Chem. Abs.*, **33**, 2669 (1939).—Magnesite or an artificial magnesia of low Fe content is treated with a mixture of Fe_3O_4 and Mn_3O_4 containing a greater molecular proportion of Mn oxide than of Fe oxide, and the mass, if desired after molding and drying, is calcined at a maximum temperature of 1400°.

Shaped article consisting mainly of vitrified amorphous silica. M. HAUSER. Brit. 503,499, April 19, 1939 (Oct. 6, 1936).

Suspended furnace roof. R. P. HEUER (General Refractories Co.). U. S. 2,154,813, April 18, 1939 (Jan. 18, 1934).

Terra Cotta

Ceramic tile in the modern American home. ANON. *Ceram. Age*, **32** [5] 133–34 (1938).—Floor- and wall-tile applications are briefly described. Illustrated. F.G.H.

Crazing and peeling. H. CHATENET. *Arts du Feu*, **1** [3] 93–96 (1938).—The opinions of several authors concerning the intermediate layer (between body and glaze) are discussed. C. did not detect such a layer by microscopic investigation. The porous whiteware body does not absorb the glaze by suction. Grains of quartz or feldspar are not attacked by glazes. No mixtures of glasses of different compositions were noticeable. Crazing and peeling are conditioned by expansion, tempering, and annealing. F.E.V.

Glaze fault due to the Alsing cylinder. ANON. *Keram. Rundschau*, **45** [32] 361–62 (1937).—As milled sand was not available, the batch for a soft porcelain glaze had to be milled in the Alsing cylinder for an abnormally long time. The brilliancy of the glaze deteriorated on account of the increase of silica due to the flint pebbles (controlled by weight). The wear of the porcelain lining of the Alsing cylinder could not be measured. See "Grinding—," *Ceram. Abs.*, **15** [5] 159 (1936). F.E.V.

Manufacture of acidproof chemical stoneware. ANON. *Ind. Chemist*, **14** [167] 512–14 (1938).—The new plant of the Royal Doulton Potteries, Erith, Kent, situated on a site of about 25 acres, is described. Modern manufacture of a great variety of chemical stoneware is shown. H.E.S.

Manufacture of flowerpots. V. *Argile*, No. 191, pp. 23–27 (1939).—The manufacture of flowerpots has been greatly improved by the use of the Schuster press which has an output of 1800 small pots per hour; only two men are needed to operate it. Machine-pressed pots are more perfectly finished than those made by hand; drying is more rapid, porosity is suitable, and interior and exterior surfaces are smooth. Decorative pots can also be made by the press. M.V.C.

Prevention of crazing in grog tile manufacture. ANON. *Keram. Rundschau*, **46** [28] 311–14 (1938).—Compositions are given for bodies, engobes, and glazes fired at cone 07a (960°C) and higher. Correction by engobes is not satisfactory. Alkali components must be avoided or limited to 4%. An addition of quartz flour is often necessary. If the biscuit firing is correct (disappearance of CO_2 evolved by lime carbonate), the glaze firing may be reduced. F.E.V.

Stoneware cock. DOULTON AND CO., LTD. *Ind. Chemist*, **14** [158] 122–23 (1938).—A new stoneware cock is a specially constructed stoneware ring to which a metal handle is attached; gentle pressure on the handle allows the tap to turn freely. The cock is fitted with a safety device and can be obtained in many sizes and types; there is no restriction of flow of the liquid. Illustrated. H.E.S.

SEPARATE PUBLICATION

Basic specifications for tile work. ANON. *Tile Manufacturers' Assn., Inc., Pub.*, No. *K*-300, 24 pp.; reviewed in *Ceram. Age*, **30** [5] 149 (1937).—The latest available information and standards are described under (1) terms, (2) scope, (3) materials, and (4) installations. F.G.H.

PATENTS

Ceramic manufacture. H. R. FEICHTER (United States Quarry Tile Co.). U. S. 2,156,149, April 25, 1939 (Jan. 14, 1938).—A ceramic block having a back face, polygonal side faces bounding the back face, and border ledges for more than two of the side faces, each border ledge being adjacent a side face and having a portion projecting inwardly over a portion of the back face.

Flat interlocking roofing tile. CARL LUDOWICI K. A. A. Ger. 670,496, Dec. 29, 1938 (July 4, 1932); V/37*c*. 1.01.—A design is given for an interlocking roofing tile. D.A.B.

Whiteware

Conduction of electricity in polar crystals. N. F. MOTT. *Science Progress*, **32** [128] 648–59 (1938).—M. discusses the theory of the conduction of electricity in nonmetals from a standpoint of quantum mechanics. The photoconductivity phenomenon serves as an illustration of the existence of conduction levels in insulators. This theory of conduction is considered for rock salt and similar minerals. Illustrations and a bibliography are presented. C.H.R.

Gas washer has ceramic tile. CARNEGIE-ILLINOIS STEEL CORP. *Steel*, **102** [6] 64 (1938).—A new gas washer operating in conjunction with a blast furnace can clean 75,000 cu. ft. of blast-furnace gas per minute. The gas enters the washer at the bottom and passes upward through a series of blanks of specially designed ceramic tile and spray nozzles. After leaving the washer the gas is further cleaned with electric precipitators. H.E.S.

Glaze and simplified process for porcelain insulators. ANON. *Ceram. Age*, **32** [2] 43 (1938).—A copper-oxide glaze which is matured during normal firing provides a radio inteference-proof insulator. Illustrated. See "Manufacture —," this issue, p. 188. F.G.H.

Installation for control of hygienic exposure arising from the application of pottery glazes. S. C. ROTHMANN. *Ind. Med.*, **8** [1] 8–12 (1939).—By this example and its practical application, R. desires to show that the atmospheric lead concentrations due to glaze mists can be kept within reasonably safe hygienic limits for the worker. In 1919 the U. S. Public Health Service made a study of the lead hazard in 92 potteries in four states; 139 cases of positive lead poisoning, 106 presumptive cases, and 168 suggestive cases were found in a group of 1809 persons employed in glaze preparations, in dipping, and in the glost department. These figures stimulated pottery managements to exert every effort for control of the lead risks. Fritted glazes, which render the raw lead relatively insoluble, are in much more general use. The so-called mechanized or automatic method of glaze application has resulted in improved control of the lead concentration or mist in the air in the worker's vicinity. Glazes are oxides of silicon, aluminum, calcium, potassium, sodium, and boron. The percentage of silica in a typical glaze is often 61% and that of lead oxide, 11%. These oxides fuse into a glasslike substance called "frit," which is subsequently ground and becomes one constituent of the glaze. In the chemical combination of the raw materials of glazes, the lead is transformed into a compound which is relatively difficult to dissolve, perhaps a disilicate. In preparing the frit, the ingredients are weighed, and the batch is mixed; in the more modern plants it is shoveled directly into a slowly revolving rotary furnace for further mixing and fusing. After being rapidly cooled in water, it is ground and pulverized and then mixed in a wet ball mill with the other glaze ingredients. Formulas vary, but a standard glaze consists of feldspar, china clay, whiting, and white lead in definite proportions. After being mixed, it is ready for the dipping process (application of the glaze by hand in open tubs). At this point the new installation for applying

pottery glazes replaces the process of glazing by hand, particularly for flatware. The finely divided fluid glaze is forced under pressure from a number of jets or guns mounted in booths; every section of a piece is covered by the spray, the piece revolving as it passes the spray guns on a narrow endless band conveyer belt. Exhaust ventilation carries away the excess spray mist. Operating data for these automatic installations and atmospheric-dust concentrations for various types of pottery-glaze application are shown in tables. The total minimum occupational exposure to lead dust in the pottery industry for tile and tableware is 168.5 mg./10 cc. and the maximum exposure is 310.5 mg./10 cc. Processes involved are hand dipping, removing hollow ware from the mangle, frit making (hand shoveling), loading the rotary frit furnace, loading glaze materials into the ball mill, and hand spraying of special shapes and glazes. The actual dipping of ware by hand does not create a great deal of dust. The chief lead-dust hazard consists in the accumulation of dried glaze on the ware boards, floors, tubs, walls, and the clothing of workers from careless splashing of the glaze during the operation. The glaze recovered in a year under the new automatic spraying method amounts to 7.63 tons (about $610 in value). Intelligent inspection must be made of these installations, especially of the ventilating apparatus; otherwise, the spray glazes escape from the booths into the workroom. In many plants soluble lead compounds are still being added to fritted glazes. With such glazes used in hand dipping or with inadequately cared-for spraying machines, the danger from lead poisoning is as great as it ever was. Nine illustrations, 7 tables, 8 references.

K.R.

Laboratory porcelains for temperatures up to 2000°. W. GURR. *Österr. Chem.-Ztg.*, **41**, 411–18 (1938); *Brit. Chem. & Phys. Abs.–B*, **58** [3] 264 (1939).—The nature, properties, and applications of hard porcelain (1200°), special pyrometer porcelains (1600°), and pure oxide (Al_2O_3) bodies are described.

Leadless glazes and the use of natural Inder borate compounds. S. A. BAKHMAN AND B. I. VISHNEVSKIĬ. *Stroitel. Materialy*, **1938**, No. 4, pp. 33–38.—Frits prepared with borate compounds (pandermite, inyoite, hydroboracite, ulexite, etc.) and used under plant conditions for one year resulted in ware equal in quality to that obtained with the use of lead glazes. The charge must be well fritted to obtain transparent glass without inclusions of unmelted grains. The density of the glaze must be 30 to 33° Bé for ware with a water absorption of 9.5 to 12.5%. Good luster is obtained by daubing the saggers with glaze; the upper saggers must be covered. Underglaze colors obtained have insufficient luster. The above borate compounds can be used in their natural condition; asharite, fines of borate rock, etc., can be used after borax is obtained from them. P.B. & E.S.

Manufacture of electrical porcelain. R. L. WHITNEY. *Elec. Eng.*, **58** [1] 7–11 (1939).—At the electrical porcelain plant of the Westinghouse Electric & Mfg. Co., Derry, Pa., metallic caps are soldered to a ceramic glaze containing gold and platinum, and radio interference-proof insulators are made by placing a conducting glaze on certain portions of the insulator. P.G.H.

Origin of sweat marks on hard porcelain. E. KIEFFER AND J. CZECH. *Ber. Deut. Keram. Ges.*, **19** [2] 54–60 (1938).—Experiments resulted in the following tentative explanation of the formation of sweat marks or sulfur patches. Under strongly reducing conditions at high temperatures, SiS_2 is formed; it volatilizes on further rise in temperature in the last stages of the firing operation. After the finish of the firing operation, the volatilized SiS_2 comes in contact with air entering the kiln. The moisture content of the air also seems to play a rôle. The air does not penetrate into the saggers uniformly but enters first at the coolest side. Due to its higher gravity, the SiS_2 collects in the deepest part of the ware. The air entering the saggers causes not only deposition of solid SiO_2 but also a slight movement of the particles being deposited before they are held fast by the solidifying glaze. This explains the characteristic stream effect of the patches. Preventive measures are (1) use of low-sulfur fuels, (2) neutral or, if possible, oxidizing fire during the final stokings, and (3) lowest possible moisture content of the air. *Ibid.*, [10] 426–27.—The authors' opinion that the effect is due to the formation and volatilization of SiS_2 is confirmed by the fact that the Krister Porcelain Mfg. Co., Waldenburg, Silesia, experiences the defect in its coal-fired kilns (the fuel contains sulfur) but never in its purified (sulfur-free) coke-oven gas fired kilns. See "Testing —," *Ceram. Abs.*, **17** [3] 109 (1938). E.J.V.

Pottery for the British Empire. ANON. *Times Trade & Eng.*, **45** [903] 34 (1939).—The United Kingdom has excellent supplies of china clay, china stone, and bone ash, and a century of experience has enabled the British to make the best possible use of them. There has been an advance in the adoption of continuous gas-fired tunnel kilns and electric kilns with detachable heating units. The first all-electric pottery in the United Kingdom is being built. The progress of mechanization in the industry, while enabling the manufacturer to reduce selling prices, has not detracted from the artistry of the ware. The producer, designer, chemist, and art director coöperate in presenting new and attractive shapes and patterns. A.B.S.

Pottery, porcelain, and glass. ANON. *Pottery & Glass Record*, **21** [3] 71–72 (1939).—Retailers are urged to devote more attention to the differences between pottery and porcelain, to extend their knowledge of the multiplicity of uses of these materials and of glass, and to seek to increase sales among buyers who appreciate the artistic values of these materials, particularly ornamental porcelain and glass. A good trade might be cultivated with collectors of porcelain and glass, who would buy pieces for their collections if these were offered in a suitable manner. A.B.S.

Stresses introduced during the cooling of glazed bodies. G. R. RIGBY. *Trans. Brit. Ceram. Soc.*, **38** [2] 152–72 (1939).—When a glazed body is cooled during the glost fire, stresses are generally developed between the body and the glaze. The magnitude of these stresses is determined by the relative expansion coefficients of the glaze and body between room temperature and the softening point of the glaze. When the coefficient of expansion of the body is higher than that of the glaze, the latter, on cooling, is under a compressive stress. The increase in expansion of the body over that of the glaze is mainly ascribed to the cristobalite content of the body, which is effective in increasing the expansion over the range 100° to 300°C. For a constrained body, the resistance to crazing is proportional to the compressive stress of the glaze which, in turn, is dependent on the expansion characteristics of the glaze and the body. When a specimen is distorted by the glaze stress, the compressive stress of the glaze is reduced and the crazing tendency is increased. The distortion or bowing of standard glazed specimens on cooling may be taken as a measure of their crazing resistance, provided the thickness of glaze and body and certain strength factors relating to the body are taken into consideration. R.A.H.

Viscosity of slips. P. BRÉMOND. *Arts du Feu*, **1** [4] 122–26 (1938).—The transition is continuous between slip and plastic paste. Industrial slips are liquids possessing a certain rigidity; they have an apparent but no true viscosity. To obtain reproducible measures of viscosity it is necessary to use always an apparatus of the same kind and of the same dimensions. Temperature and p_H should be noted. Slips should not be allowed to stand on account of thixotropy. F.E.V.

PATENTS

Air-tight joints between metals and ceramic materials in components for use in high-frequency electrical circuits. TELEFUNKEN GES. FÜR DRAHTLOSE TELEGRAPHIE. Brit. 503,771, April 26, 1939 (Oct. 10, 1936).

Apparatus composed of glass and ceramic members. STEATIT-MAGNESIA A.-G. Brit. 504,177, May 3, 1939 (Sept. 12, 1936).

Ball bearing and balls of ceramic material. HEINRICH SCHRÖDER (Telefunken Ges. für Drahtlose Telegraphie

m. b. H.). U. S. 2,158,156, May 16, 1939 (Oct. 1, 1937).—A ball bearing arrangement adapted for high-frequency apparatus having fixed and movable elements comprises a support of ceramic material for the fixed element, a shaft of ceramic material for the movable element having its ends tapered, a plurality of ball bearings of ceramic material arranged on the tapered portion of the shaft and the support to provide an insulating bearing for the movable element.

Ceramic electric insulating bodies. PORZELLANFABRIK KAHLA. Brit. 502,827, April 5, 1939 (Sept. 28, 1936).

Ceramic insulating material. G. L. MCCREERY, V. E. CAMPBELL, AND RAY HIGGINS (Ohio Brass Co.). U. S. 2,155,835, April 25, 1939 (Dec. 24, 1936).—Ceramic insulating material of high specific inductive capacity in which preheated titanium oxide is combined with clay using sodium titanium silicate as an electrolyte and fluxing agent.

Closet structure. GEORGE BRAIN (American Radiator & Standard Sanitary Corp.). U. S. 2,156,108, April 25, 1939 (Aug. 21, 1936).

Glazed ceramic insulator, etc. D. H. ROWLAND (Locke Insulator Corp.). U. S. 2,157,100, May 9, 1939 (Dec. 20, 1938).—An insulator has a body of ceramic material having a low coefficient of expansion and a glaze, the latter being of ceramic insulating material having a coefficient of expansion substantially less than that of the body, the glaze being under compression throughout the normal operating range of temperature of the insulator.

Insulator. G. A. MEAD (Ohio Brass Co.). U. S. 2,155,836, April 25, 1939 (Jan. 16, 1937). D. M. MORGENSTERN AND JOSEPH BRASTY. U. S. 2,158,012, May 9, 1939 (Feb. 4, 1937). W. A. SMITH (Ohio Brass Co.). U. S. 2,155,846, April 25, 1939 (Jan. 27, 1938). J. J. TAYLOR (Ohio Brass Co.). U. S. 2,155,848, April 25, 1939 (Nov. 14, 1936).

Manufacture of water-closet basins and flushing cisterns for use therewith. E. JOHNS & CO., LTD., AND E. R. CORN. Brit. 504,356, May 3, 1939 (Oct. 22, 1937).

Producing compactly sintered ceramic masses. ROSENTHAL-ISOLATOREN GES. Brit. 502,822, April 5, 1939 (Sept. 24, 1936).

Spark plug. A. N. COOPER. U. S. 2,158,743, May 16, 1939 (July 6, 1938). E. H. FENN (United Aircraft Corp.). U. S. 2,155,481, April 25, 1939 (April 1, 1938).

Tile and means for setting. C. F. GLASER. U. S. 2,157,201, May 9, 1939 (Jan. 17, 1938).

Water closets. F. C. HARRISON. Brit. 504,215, May 3, 1939 (Jan. 31, 1938).

Equipment and Apparatus

Air conditioning in industry: II. W. L. FLEISHER, A. E. STACEY, F. C. HOUGHTEN, AND M. B. FERDERBER. *Heating, Piping & Air Conditioning*, **11** [3] 191–92 (1939).—The physiological reactions of nine workers to high effective working temperatures are reported. Test procedure and conditions, physiological observations, and activity of the subjects are described. 1 table, 4 photos. For Part I see *Ceram. Abs.*, **18** [6] 168 (1939). J.L.G.

Applications of the microscope in industry. C. H. BUTCHER. *Ind. Chemist*, **14** [164] 344–48 (1938).—B. reviews the wide application and scope of the microscope in the glass, feldspar, porcelain, refractories, coal, concrete, metals, etc., industries. H.E.S.

Automatic control of resistance furnaces. ANON. *Z. Ver. Deut. Ing.*, **80**, p. 240 (1936); abstracted in *Elec. Rev.*, **118** [3057] 942 (1936).—The use of a thermionic rectifier in the automatic regulation of electric furnaces, using an electric resistance thermometer to control the grid potential and thus increase or decrease the furnace current, is described and illustrated by schematic diagram. The arrangement is applicable for furnace temperatures up to 1472°F. Higher temperatures require the use of a bolometer or photocell to control the rectifier. Temperature can be kept constant at 1472°F ± 9°F. J.L.G.

Deairing heavy clay bodies. F. GAREIS. *Ber. Deut. Keram. Ges.*, **19** [9] 396–408 (1938).—G. describes a vacuum process in which deairing and shaping are separated and in which compression or consolidation follows immediately after the deairing by the action of a sudden increase in pressure, *e.g.*, atmospheric pressure. An advantage of the method is that it can be applied at any point during the manufacturing process, even after the piece has received its final shape. Ceramic bodies (even pieces of large dimensions) can be completely evacuated of air with ease. A body formed of plastic ceramic material, when deaired in a desiccator, swelled up, and a number of large and small cracks appeared in it. When the vacuum was suddenly released by opening a tap, the body shrank together again, the cracks closed, and the body resumed its original form. After this treatment, it had the toughness and plasticity of bodies passed through the brick machine. In large-scale experiments with pieces 50 x 30 x 30 cm., similar results were obtained. Studies on plastic masses showed that the air permeability of evacuated clay seems to be dependent upon the difference in pressure prevailing between the interior of the specimen and the outside atmosphere. One condition of successful deairing, however carried out, is that the clay must be free to expand; this explains the necessity of providing means for breaking up the clay into shreds, etc., in the ordinary deairing machine. Vacuum treatment by the new process gave an increase of 11% in tensile strength. Comparative figures for spalling tests were obtained for the following cases: (*a*) body treated in an ordinary brick machine (not deaired), cut into lumps, and pressed in an automatic press to exact shape; (*b*) body deaired in a brick machine, cut into lumps, and then pressed to exact shape in an automatic press; (*c*) body treated in an ordinary machine (not deaired), cut into lumps, pressed in an automatic press to exact shape, and then deaired by the new process and compressed. The figures for a highly refractory fire-clay (grog) body were (*a*) 22 quenchings, (*b*) 26 quenchings, and (*c*) 70 quenchings. In another series of tests, method *b* was modified as follows: body treated in a brick machine (not deaired), cut into blocks, deaired by the new method, and finally pressed to shape in an automatic press. Quenching values of a similar refractory material tested in this series were (*a*) 24, (*b*) 56, and (*c*) 66. Another refractory body gave values of (*a*) 13, (*b*) 26, and (*c*) 34. A large number of bodies was tested by the last method. The increase in spalling resistance expressed as a percentage of the number of quenchings obtained on the unevacuated body, was (1) 18% for material deaired on a deairing brick machine; (2) 116% for material roughly formed and shaped, deaired in a vacuum boiler and compressed by air, and finally pressed to exact shape in an automatic press; and (3) 190% for material first formed into exact shape and then deaired and air-compressed by the new method. These figures show clearly that the less forming or shaping treatment the body receives after deairing, the greater the number of quenchings it will withstand. When a material is compressed after deairing by the sudden application of atmospheric pressure, force is exerted upon it uniformly in all directions. This implies the complete release of all stresses in the body. Further handling of the material after deairing merely upsets this equilibrium and reintroduces stresses which weaken the body. This explains not only why a vacuum-treated body shows better resistance to spalling and greater tensile strength but also why it is less sensitive to drying treatment. Compared with the ordinary deairing brick machine, the new method offers the following improvements: (*a*) it is applicable to handmade products; (*b*) it guarantees freedom from cavities; (*c*) it greatly increases the spalling resistance (number of quenchings); and (*d*) it reduces the sensitivity to drying, which suggests its applicability to the manufacture of glass pots, glass tank blocks, etc. E.J.V.

Dial thermometer. E. H. HAMMOND. *Power*, **81**

[8] 430–31 (1937).—The various types of dial thermometers are briefly reviewed. Illustrated. F.G.H.

Dielectric properties of insulating materials. E. J. Murphy and S. O. Morgan. *Bell System Tech. Jour.*, **17** [4] 640–69 (1938).—The variation of dielectric constant and dielectric loss in the radio- and power-frequency range is discussed with the object of giving a simple picture of the type of mechanism which is able to produce anomalous dispersion in this range of frequencies. Some of the general characteristics of anomalous dispersion can be demonstrated as well on a simple and arbitrary model of the structure of dielectrics as on the complex models which correspond more closely to the actual structure of dielectrics. Such a derivation is given to indicate the significance of the factors occurring in the formula which have been proposed to account for the variation of dielectric constant and dielectric loss with frequency. See *Ceram. Abs.*, **18** [3] 86 (1939). H.E.S.

Driving belts and pulleys. Edward Ingham. *Brit. Clayworker*, **48** [564] 7–9 (1939).—When the flesh side of a belt is next to the pulley, it transmits only from 58 to 68% of the power transmitted when the hair side is next to the pulley under the same conditions. The vertical belt drive transmits about 12% less power, under average conditions, than the horizontal drive with $7^1/_2$-ft. centers. A vertical belt is more sensitive to tension than a horizontal belt and should therefore be retightened more frequently. The lurching of belts, the driving of nonparallel shafts, and imperfectly balanced belt pulleys are described, and remedies for the conditions are given. R.A.H.

Electric arc furnaces. A. Karsten. *Ind. Chemist*, **14** [164] 349–51, 369 (1938).—Modern electric arc furnaces can be classified as (1) those with direct heating, (2) those with indirect heating, and (3) electric arc reduction furnaces. Their principles and uses are explained. Their use offers the prospect of a cheaper mass production of the important high-grade ferroalloys and thereby a more favorable development of the whole alloyed-steel industry. Illustrated. H.E.S.

Electric gas analyzer G E D—I. A. S. Savel'ev. *Tsement*, **5** [10] 22–30 (1938).—The device is adapted for continuous control of the CO_2 and $CO + H_2$ contents in flue gases of rotary cement kilns. The continuity of analysis is insured by a special feeding device which sucks up the gas from the dust chamber of the kiln with the aid of a water-jet pump. The analysis takes place in the feeders equipped with a Wheatstone bridge electric arrangement fed with direct current. Checking electromagnetic devices (based on the Depré d'Arsonval principle) which give readings of CO_2 and $CO + H_2$ percentages are enclosed in the circuit. P.B. & E.S.

Electrical precipitation of dusts. H. J. Bush. *Ind. Chemist*, **14** [158] 97–100 (1938).—Applications to industrial effluent gases are described. H.E.S.

Electroösmosis and molding of ceramic ware in metal molds. I. D. Finkelsteĭn and A. F. Chicherin. *Stroitel. Materialy*, **1938**, No. 6, pp. 5–10.—Metallic molds are more durable and permit the molding of ware having a lower moisture content than that molded in gypsum molds. Ware of a better appearance is obtained, and the method can be used for molding complicated shapes. The process is conducted on the molding bench. The mold is used as a cathode and the pattern as an anode. P.B. & E.S.

Experiments on the abrasion of metals. H. E. Smith. *Internat. Assn. Testing Materials, London Congr., 1937*, p. 148; *Nat. Phys. Lab. Abs. Papers*, **1937**, p. 38.—Experiments were carried out on a machine similar in principle to the Amsler abrasion machine, mainly on a 0.28% carbon steel with a Brinell hardness number of 100. Abrasion tests were made on pairs of specimens of this material; the specimens were $1^3/_4$ in. in diameter and $^1/_2$ in. wide; the load between them was 60 lb., and the speed was 300 r.p.m. with a slip of 5% between the specimens. Under these conditions the coefficient of friction rose from a value of 0.03 at the beginning of the test to 0.28 after $2^1/_2$ hr. During this period a gray film of oxide formed on the surfaces of the specimens. Subsequent tests gave a greater rate of wear because the oxide film was already formed. Over a long series of tests, the rate of wear, expressed as the loss of weight in grams/1000 revolutions, varied from 1.04 to 3.00. Attempts to carry out tests in an atmosphere free from oxygen were unsuccessful. Tests were also made under pure sliding, when a completely different type of wear (mechanical wear) took place. Within certain limits, the amount of wear was proportional to the load.

Filters and driers. G. Netzel. *Ber. Deut. Keram. Ges.*, **19** [3] 97–103 (1938).—Modern rotary driers are described. In the Imperial Aeroform drier the body is removed from the drum in the form of bars about 5 x 6 mm. in cross section and 30 to 80 mm. long. Economies in both labor and material are afforded by modern machines. For ordinary filter presses, cloths weighing 300 to 600 g./m². are needed, whereas cloths weighing only 100 to 150 g./m². are adequate for modern driers. Rotary filters require only about $^1/_{10}$ to $^1/_4$ of the filtering area for a given output, and the time required for processing the body is reduced considerably. Illustrated. E.J.V.

Gas-actuated dial thermometers. E. H. Hammond. *Power*, **81** [11] 678–80 (1937).—The construction characteristics and applications of gas-actuated dial thermometers are discussed. Illustrated. F.G.H.

Industrial induction furnaces. A. Clergeot. *Electricité*, **22** [40] 25–32; [42] 99–101 (1938).—C. describes in detail the construction, application, and economy of low and high frequency induction furnaces, with and without magnetic cores. He deals with both American and foreign systems. The refractory problems are mentioned, and the shape of the lining is shown. Illustrated. J.M.N.

Laws governing the grain size of pulverized materials. E. Rammler. *Z. Ver. Deut. Ing., Beiheft Verfahrenstech.*, **1937**, 161–68; *Chem. Abs.*, **32**, 409 (1938).—R. presents a restatement of the exponential expression describing grain fineness, with two tables giving data for glass, feldspar, quartz, flint, and gypsum, with both wet and dry grinding for some cases, and illustrations of the rapid graphic solution of constants for determining grain size and mill surface.

Low-frequency induction furnace (Siemens type). A. Sevastopoulo. *Jour. Four Élec.*, **47** [3] 88–92 (1938).—S. describes in detail the auxiliary equipment, the construction of the furnace and its application for nonferrous alloys, brazing, and the melting of zinc and aluminum. Economic data are given for the different processes. Illustrated. J.M.N.

Lubrication. .C. C. Pecu. *Steel*, **102** [11] 50–53 (1938).—Low-viscosity and high-film strength lubricants are used on high-speed mills for the purpose of conducting away the heat developed by friction. H.E.S.

Measurement of the fineness of powdered materials. H. Heywood. *Trans. Inst. Mech. Engrs.* [Preprint], **140**, 257–309 (1938).—H. describes various methods for measuring the fineness of powdered materials and discusses definitions of particle size and shape; distribution graphs are shown. The relations between particle size and sieve aperture for different substances are shown, and the equivalent sizes of round, square, and slotted apertures are stated. A method for calculating the falling velocity of particles when the flow around them is turbulent is given. Elutriation by air and water, sedimentation, hydrometer readings, and the obscuring of a beam of light are described as means of determining particle size, and the relative advantages and disadvantages are discussed. The paper is descriptive rather than critical. 17 figs., 10 tables, 150 references. A.B.S.

Mercury-actuated dial thermometers. E. H. Hammond. *Power*, **81** [9] 496–98 (1937).—Practical information on the construction and operation of mercury-actuated dial thermometers is given. Illustrated. F.G.H.

Metal spraying. J. G. Magrath. *Welding Jour.* [N.Y.], **17** [6] 16–21 (1938).—M. reviews and discusses details of practice for successful spraying. The procedure for spraying for corrosion, heat, and wear resistance is outlined. Building up worn parts is a large promising field of spray application, and the new (sprayed) metal may have longer life than the original metal, *e.g.*, with lubricated sur-

faces where the porosity of the sprayed surface aids in the retention of oil. Preparation of the base metal by suitable roughening is necessary before applying sprayed metal, and a survey of the previous and future use of an article must be made to assure that the mechanical conditions of use are ideal for a permanent bond between the sprayed metal and the original surface. Illustrated. W.H.B.

Methods of drying, grinding, and dust removal. T. H. TIVES. *Ber. Deut. Keram. Ges.*, **19** [3] 85–96 (1938).—T. describes new methods of drying and grinding raw materials such as sand, pegmatite, raw kaolin, raw clays, etc., and gives an outline of the development of the Barthelmess rapid clay drier. This machine combines two processes: the drying and the grinding or pulverizing of raw materials. The material is fed from a hopper through a worm to a centrifuge which acts as the first pulverizing stage. The material is thrown upward by the centrifuge into a drying tower, in which a countercurrent of hot gases is encountered. Depending on the particle size and moisture content of the material, it is either returned to the centrifuge or passed to the second pulverizing stage and from there to the cyclone. T. also describes the Krupp drying and grinding cylinder. The raw material passes from a storage bunker through a chute to the cylinder, the lining of which, together with the grinding media, can be of ceramic material or flint. At the opposite end of the cylinder, hot or cold air is blown in to remove the dust to a separator. The coarse material is returned from the separator to the mill for further grinding. A new mill for very fine grinding is still in the experimental stage but has proved successful for grinding colors. The grinding elements consist of an upper and a lower grinding ring between which run the grinding pebbles, the arrangement of the elements thus resembling that of a thrust ball bearing. A bag filter constructed of light concrete is briefly described. Illustrated. E.J.V.

Microid polarized light apparatus. GRIFFIN AND TATLOCK, LTD. *Engineering*, **141**, 584–86 (1936).—The Microid polarized light apparatus is described in which the more important phenomena with polarized light may be projected on a screen so as to be visible to a large class. Calibrated sheets of cellophane instead of selenite or mica are used for making exceptionally large quarter-wave plates required for producing circularly polarized light. By the use of these sheets, conveniently mounted in the form of slides, the stresses in strained celluloid models can be measured and experiments on photoelasticity made. The stress distribution can be measured and mapped and useful information on the strength of materials and the principles of structural design can be obtained. Illustrated. H.E.S.

Optical harmonic analyzer. H. C. MONTGOMERY. *Bell System Tech. Jour.*, **17** [3] 406–15 (1938).—An instrument which makes a Fourier series analysis of a function by optical means is illustrated and described. H.E.S.

Periodic mixers in refractory plants. EISENBACH. *Ber. Deut. Keram. Ges.*, **18** [7] 322–27 (1937).—E. discusses the old methods of mixing dry materials and describes mechanical mixers which have come into use in recent years. Illustrated. E.J.V.

Preparation, mixing, and deairing of ceramic bodies by means of the clay disintegrator, vacuum presses, and pugmill. G. WELZEL. *Ber. Deut. Keram. Ges.*, **19** [4] 131–44 (1938).—The Tonraspler (clay disintegrator), which combines the operations of a feeder, a mixer, and a disintegrator, is widely used in Germany. Inside the pan are specially shaped revolving arms fitted with "shoes" at the ends. The bottom portion of the wall of the pan is perforated to form a screen. As the arms revolve, the shoes press the clay through the perforations with a grating action. The material is partially mixed by the revolving arms, and mixing is completed by a rotating table beneath the pan, which collects the clay shreds as they are forced through the pan wall. This machine is unsuitable for stony or very hard materials; these must first be passed through a crusher or an edge runner. In many cases the "Raspler" has replaced roll crushers and edge runners. Recent developments in deairing machinery in America and Germany are briefly outlined. E.J.V.

Protected heating elements and their technical applications. R. GAUTHERET. *Electricité*, **22** [50] 357–63; [51] 399–402 (1938).—G. reviews the heating elements on the market and classifies them, according to their insulation, as heating elements with mica, heating elements with refractories, and heating cables. Tables of sizes, energy consumption, and highest possible temperatures and the principal applications in the household and in industry are given. J.M.N.

Pyrometric cones. M. WINTERER AND R. POPINEAU. *Arts du Feu*, **1** [2] 58–59; [3] 76–77; [6] 193–202 (1938).—The pioneer work of Lauth and Vogt, Seger, Cramer and Hecht, and Simonis is described. The correct position of cones is that advocated by Fairchild and Peters (*Jour. Amer. Ceram. Soc.*, **9** [11] 701–43 (1926)). The fixation is described in detail. Zimmer, Hoffmann, Rieke, and others showed that pyrometric cones fall at lower temperatures if the increase of temperature is slow; this is the case in industrial furnaces. Cones are artificial mixtures of carbonates and silicates; they have no definite melting points. The experiments of Rieke, Fairchild and Peters, Sosman, Shepherd and Rankin, Bowen and Greig, Cole, and Geller and Pressler are described. Sosman verified the theory that heating duration lowers the melting point more if the cone composition is near a eutectic. The fact that cones are sensitive to heating duration increases their value for the control of ceramic firing. There is a difference, however, between pyrometric cone partial melting and the maturing of ceramic products by firing. Cones and pyrometers should be used simultaneously. 33 references. F.E.V.

Rapid reaction agglomerating furnace. SOC. DES ACIERIES DE LONGWY. *Ind. Chemist*, **14** [162] 268–71 (1938).—A new type of furnace for agglomerating large quantities of dry dust collected from the downcomer flues and electrostatic dust catcher of a blast-furnace plant and for the calcination of chalk, limestone, etc., is described. The basic feature of the method is the comparatively large surface per unit of weight of material that is presented to the action of hot gases in a confined space; this is achieved by injecting the material tangentially in a fine state of division into a vertical cylinder shape in countercurrent to an ascending spiral of hot gases. H.E.S.

Reducing radiation errors in gas-temperature measurement. W. L. SEVERINGHAUS. *Mech. Eng.*, **59** [5] 334, 358 (1937).—A means of reducing the seriousness of radiation errors is described in detail. Illustrated. F.G.H.

Routine sampling atmosphere impurities. ANON. *Bull. Amer. Ceram. Soc.*, **18** [5] 177–78 (1939).

Size analysis by photographic sedimentation. W. F. CAREY AND C. J. STAIRMAND. *Ind. Chemist*, **14** [159] 141–42 (1938).—The principle adopted is to photograph the tracks of particles as they fall in a stagnant liquid under the action of gravity. The length of the track of a particle for a definite exposure time is a measure of its falling speed and enables the diameter of the equivalent sphere to be calculated. The main difficulty is the prevention of convection, which may be greatly increased by the intense illumination necessary. The method has been applied to a size range of 0.2 μ to 5.0 μ. H.E.S.

Spectrochemical analysis in communication research. B. L. CLARK AND A. E. RUEHLE. *Bell System Tech. Jour.*, **17** [3] 381–92 (1938).—The development of spectroscopy is traced through Newton, Fraunhofer, and Kirchoff to Hartley, Pollock and Leonard, and DeGramont who, in the period from 1880 to 1920, applied the spectroscope to chemical analysis. Modern quantitative spectrochemical analysis began with the comparison standard method of Meggers in 1922; developments since that time are discussed. H.E.S.

Temperature corrections in optical pyrometry. FRANK BENFORD. *Jour. Optical Soc. Amer.*, **29**, 162–63 (1939).—Optical pyrometers give incorrect readings when the surface being tested is viewed through glass because of losses of light at the two glass surfaces. B. gives a chart for

correcting the readings, with examples of its use for such corrections and for calculating emissivities. Another chart aids in correcting for observations taken at an angle from the normal line of sight through glasses of various refractive indices. Indices of eight Corning glasses used in experimental work involving heated filaments are given. A.P.

Temperature measurements on gases in the laboratory and in industry. G. RIBAUD. *Usine*, **48** [12] 33–35 (1939).—Methods, instruments, equipment, and principles and theories involved are explained. Mercury thermometers can be used for temperatures up to 300°C, pressure thermometers (gas) up to 500°, thermocouples of Ni-Cr or Fe-constantan up to 1100°C, and Pt-Pt Rh couples up to 1600° with special precaution over 1400°; above 1600° optical or radiation pyrometers can be used. M.H.

Testing the fineness of air-blown materials. J. HEYD. *Tonind.-Ztg.*, **61** [100] 1105; [102] 1129; [103–104] 1138 (1937); *Keram. Rundschau*, **46** [21] 234–36; [22] 247–48; [24] 269–70 (1938).—The determination of granulometry by sieving is reliable up to 0.04 mm. at the most. H. describes the methods used for finer grains, *viz.*, air blowing, flotation, painting, and the optical test with a microscope and a scale. F.E.V.

Vacuum deairing of clay and foliation. O. MANFRED. *Ber. Deut. Keram. Ges.*, **19** [8] 342–44 (1938).—M. discusses photographs illustrating the structure of clay given in support of his previous paper ("Deairing—," *Ceram. Abs.*, **17** [3] 110 (1938)). E.J.V.

Vapor pressure-actuated dial thermometers. E. H. HAMMOND. *Power*, **81** [10] 614–16 (1937).—H. gives details concerning the construction and the operation of vapor pressure-actuated dial thermometers. Illustrated. F.G.H.

BOOKS

Spectroscopy in Science and Industry. Edited by GEORGE R. HARRISON. Technology Press; John Wiley & Sons, Inc., New York, 1938. 134 pp. Price $3.00. Reviewed in *Jour. Amer. Chem. Soc.*, **60** [8] 2007–2008 (1938).—This book comprises the proceedings of the Fifth Summer Conference in Spectroscopy and Its Applications, held at Massachusetts Institute of Technology, Cambridge, Mass., in July, 1937. F.G.H.

Standard test card for disk and propeller fans, centrifugal fans, and blowers. Prepared by the National Assn. of Fan Manufacturers and the American Society of Heating and Ventilating Engineers. 2d ed. 20 pp. Price 25¢. Reviewed in *Power*, **81** [3] 161 (1937).—Complete test methods for fans and blowers are outlined by means of charts, diagrams, and formulas. F.G.H.

Theory and Performance of Axial-Flow Fans. C. KELLER, L. S. MARKS, AND J. S. WESKE. McGraw-Hill Book Co., Inc., New York, 1937. 140 pp. Price $4.00. Reviewed in *Mech. Eng.*, **59** [10] 785 (1937); *Power*, **81** [11] 709 (1937). F.G.H.

PATENTS

Abrading apparatus. C. H. HAMMELL (American Foundry Equipment Co.). U. S. 2,154,843, April 18, 1939 (March 21, 1936).

Apparatus for abrasively treating metallic objects. D. C. TURNBULL (American Foundry Equipment Co.). U. S. 2,154,878, April 18, 1939 (June 17, 1936; renewed Nov. 19, 1938).

Apparatus and method for making rustic brick. H. BRISCOE. Brit. 503,028, April 13, 1939 (Oct. 6, 1937).

Apparatus for treating metal articles. D. C. TURNBULL (American Foundry Equipment Co.). U. S. 2,154,879, April 18, 1939 (July 14, 1936).

Conveyer chain. J. S. HARKER AND L. C. VAN GORDEN (Kimble Glass Co.). U. S. 2,154,844, April 18, 1939 (March 29, 1937).

Deaired wire cutting press for claylike masses. KARL HÄNDLE & SÖHNE MASCHINENFABRIK UND EISENGIESSEREI. Ger. 670,670, Dec. 29, 1938 (Nov. 18, 1937); VI/80*a*. 26.—A deaired wire cutting press is described in which the masses go through a preliminary press, a divider, a degassing chamber, and a main press. Two mixing and auger spiral shafts go through the entire diminished-pressure press, running in the same plane beside each other, revolving in opposite directions, and meshing into one another. D.A.B.

Disintegrating and deairing of earth, minerals, and ceramic materials (with extraction of clay). KARL SCHULZ. Ger. 669,011, Nov. 24, 1938 (Nov. 1, 1937); VI/80*b*. 12.01. Addition to Ger. 652,074 (*Ceram. Abs.*, **17** [6] 224 (1938)).—This patent is an application of Ger. 652,074. D.A.B.

Drying ceramic products by means of an electrical alternating field of high frequency. BERTHOLD WEBER AND HANS-JOACHIM REUSCH (Siemens-Schuckertwerke A.-G.). Ger. 669,013, Nov. 24, 1938 (May 25, 1937); V/82*a*. 1.01.—A method is given for drying ceramic products, especially porcelain products, by means of an electrical alternating field of very high frequency. Means are provided for avoiding a heat or moisture exchange between the surface of the ceramic object and its surroundings during or after the high-frequency treatment, so that the temperature and moisture differences between the interior of the object and the exterior cross-sectional parts are eliminated. D.A.B.

Finely divided fused substances. DEUTSCHE GOLD- UND SILBER-SCHEIDEANSTALT VORM. ROESSLER. Fr. 832,799, Oct. 3, 1938; *Chem. Abs.*, **33**, 2378 (1939).—The fused substance (metal, alloy, metal compound, glass, resin, etc.) is sprayed onto a rapidly rotating disk cooled by a refrigerating liquid sprayed onto the disk at the same time as the substance or by a cooling gas passed through the spraying chamber.

Fusion furnaces using high-frequency currents. SOC. QUARTZ ET SILICE. Fr. 832,510, Sept. 28, 1938; *Chem. Abs.*, **33**, 2423 (1939).

Method and apparatus for blunging and decolorizing clay, etc. S. C. LYONS (Bird Machine Co.). U. S. 2,154,948, April 18, 1939 (May 8, 1937).—A method of treating clay carrying colored impurities of the nature of ferric oxide comprises treating such clay as an acidic aqueous suspension containing an electrolyte, which is capable of generating nascent reducing agent at a cathode and reducing ferric iron to the ferrous state, between at least one pair of relatively moving electrode surfaces clearing each other by a narrow gap, at least one of which electrode surfaces is a cathode, thereby subjecting the clay particles to hydraulic shearing action while simultaneously exposing the clay particles to the nascent reducing agent being generated at the cathode surface, and thus reducing and dissolving, as substantially colorless compounds in the aqueous suspending medium, the colored impurities carried by the clay.

Spectrophotometry. R. H. PARK (Calco Chemical Co., Inc.). U. S. 2,157,389, May 9, 1939 (Jan. 14, 1938). A differential recording spectrophotometric system comprises monochromating means for passing bands of monochromated light of equal wave length through two photometric systems of the flickering-beam type, each system being provided with a rotating photometering element driven by an electric motor actuated from amplified flicker frequency current through a drive of varying ratio so that the movement of the motor shaft is in proportion to the ratio $A_1 - A_2/1 - A_1$, where A_1 is the fraction of incident light absorbed by a colored standard and A_2 is the fraction of light absorbed by a colored sample, in the case of the first system, and to the ratio $1 - A_1/1 - A_0$, where A_1 is the fraction of light absorbed by a similar colored standard and A_0 is the fraction of light absorbed by a white standard, in the case of the second system, splines on one of the motor shafts, a bevel gear movable on but keyed to the splined portion of the shaft, a bevel pinion meshing with the gear and driving a threaded shaft at right angles to the splined shaft, the shaft being journaled in a movable frame and containing a movable nut thereon, the second movable shaft being provided with a threaded portion, the frame having an arm journaled on the splined shaft but not keyed thereto and carrying a nut on the threaded portion on the second shaft, a drum for carrying a recording surface

having its axis parallel to the threaded shaft driven by beveled gears, the drum having driving connection with the monochromating means so that the rotation of the drum is in proportion to the travel of the bands of monochromated light through the spectrum, a rigidly mounted frame parallel to the surface of the drum and spaced a short distance therefrom, a supporting stylus movable along the frame and engaging the recording surface, a bushing attached to the stylus and capable of rotating thereon about an axis perpendicular to the axis of the drum, a rod journaled in the bushing, and a fulcrum on the movable frame, the rod passing through the fulcrum and being attached to the nut on the threaded shaft driven by the beveled gears.

Kilns, Furnaces, Fuels, and Combustion

Carbon burned per pound of coal. E. R. Stone. *Power's Data Sheet*, No. 56; *Power*, **81** [5] 276 (1937).—A graphical solution for determining the amount of carbon burned per pound of coal is presented. F.G.H.

Ceramic kiln. Anon. *Electricité*, **22** [50] 377 (1938).—The art-pottery works in Thiais (Seine) uses an electric kiln (Druelle) with a capacity of 1.65 cu. m. and a power of 45 kw.; the power and the temperature are regulated by a potential regulator. The furnace is used for firing (biscuit and funeral ware) and glazing (enamel and gold). The temperature rises to 900° to 1000°C in 10 to 12 hr., according to the nature of the ware. The energy used is 360 to 450 kw.-hr. The furnace is working only at night to benefit by an advantageous tariff. J.M.N.

Coal selection for the industrial plant. T. A. Marsh. *Power*, **81** [3] 126–28 (1937).—Fundamental factors in the selection of coal are reviewed. F.G.H.

Design and firing of kilns: XIV. Anon. *Brit. Clay worker*, **47** [563] 366–67 (1939).—Factors to be considered when choosing between a Hoffman kiln of the gallery or ring type and a Zig-Zag kiln are pointed out. **XV.** *Ibid.*, **48** [564] 5–6 (1939).—The description of the grate-fired continuous kiln which may be fired exclusively with wood is continued. A brief review of the development of the continuous tunnel kiln is also given. For Part **XIII** see *Ceram. Abs.*, **18** [5] 135 (1939). R.A.H.

Electric kilns in the ceramic industry. R. Buchkremer. *Ber. Deut. Keram. Ges.*, **19** [7] 271–83 (1938).—B. outlines the fundamental principles underlying the development of the electric kiln and describes the development of the periodic electric kiln for ceramic purposes. A battery of enamel kilns of 0.3-cu. m. capacity, used for art porcelain, is described. The heating elements can be arranged in any manner to give completely uniform temperature distribution. An oxidizing atmosphere is maintained in the kiln by drawing off the fumes from the colors at intervals. Brief descriptions of electric muffles and electric hearth-truck kilns are given. In the electric firing of porcelain, important factors are the kiln atmosphere at the different firing periods, the temperature, and the temperature curve. The melting point of the glaze is about 1250°, and before this temperature is attained a reducing atmosphere is necessary. In some cases the reducing period can begin shortly after 1000° is passed. The most convenient reducing medium is town gas. Advantages obtained in glost firing in electric kilns include elimination of sagger, low construction costs, reduced wage costs, and better quality of ware due to automatic regulation of the firing. Illustrated. E.J.V.

Electrothermal processes. J. W. Cuthbertson. *Jour. Inst. Elec. Engrs.* [London], **80**, 211–17 (1937).—Progress in electric heating furnaces is reviewed. Overglaze pottery decoration is fired at 800°C in tunnel kilns, and glass bottles are annealed in lehrs at 550°C; both are heated by nichrome wire elements. L.R.B.

Fuels in technical industrial plants: III, Liquid fuels. K. Schulze and F. H. Zschacke. *Glashütte*, **68** [43] 745–47; [44] 761–63 (1938).—The properties of liquid fuel, *viz.*, viscosity, specific gravity, flash point, solidifying point, calorific power, chemical composition, and sulfur, dirt, ash, and water contents, must be determined before the oil can be used. Testing methods and apparatus for determining these properties are described. Fuels for industrial furnaces are derived from petroleum by distillation and other processes and consist of residues with higher boiling points. Shale tar oil distilled from bituminous shale is another source of fuel oil. The distillation of brown coal and the liquefaction of coal supply other liquid fuels. See "Analysis —," *Ceram. Abs.*, **15** [11] 342 (1936); "Investigating —," *ibid.*, **16** [7] 216 (1937). M.V.C.

Gas flues. Anon. *Keram. Rundschau*, **46** [33] 368–69 (1938).—The designing of flues for nonpurified gas is discussed. F.E.V.

Ignition of fuel on grates. Discussion. J. G. Bennett, T. Barratt, J. Roberts, M. W. Travers, B. Samuels, S. Bairstow, W. Francis, E. S. Grumell, A. C. Dunningham, and P. O. Rosin. *Jour. Inst. Fuel*, **11** [57] 218–29 (1938).—The following papers are discussed: "Ignition of coal," by C. A. Seyler and T. E. Jenkins (*ibid.*, [56] 122–29); "Ignition of coal on a grate," by P. O. Rosin and H. R. Fehling; and "Ignition of fuel beds," by A. C. Dunningham and E. S. Grumell (*Ceram. Abs.*, **18** [3] 82 (1939)). H.E.S.

Sulfur extraction from gases. G. E. Foxwell and A. Grounds. Read in a symposium on "Gas Purification from Oil and Sulfur," Manchester, England, March, 1939; *Chem. Trade Jour.*, **104**, 237–38 (1939).—In the Thylox process, hydrogen sulfide is removed from coke-oven gas, etc., by a solution of ammonium thioarsenite; sulfur in a fine state of subdivision, particularly suitable for insecticides, is subsequently liberated quantitatively by air in warm solution, and the thioarsenite is regenerated. Cyanides are also removed. The process is cheap. The content of H_2S can be reduced to 8 grains per 100 cu. ft. L.R.B.

Utilization of waste heat in the ceramic industry. S. Reineck. *Ber. Deut. Keram. Ges.*, **19** [7] 254–59 (1938).—The German AKHA system of utilizing waste heat from various types of kilns is described. Specially designed fans in suitable casings, with air-cooled bearings, are shown. By means of a patented connection to the kiln, fresh air is mixed with the hot air from the kiln to cool it to a serviceable temperature. A working diagram for round kilns shows the exact time for setting the kiln, firing, and cooling, with and without fans. E.J.V.

BOOKS

Gas Tables; Physical, Thermodynamic, and Technical Burning Characteristics of Gases and Other Combustible Materials (Gastafeln; Physikalische, thermodynamische und brenntechnische Eigenschaften der Gase und sonstigen Brennstoffe). H. Brückner. R. Oldenbourg, Munich and Berlin, 1937. 152 pp. Price 12 Rm. Reviewed in *Mech. Eng.*, **59** [7] 541 (1937).—B. attempts to present all the numerical data required by the gas engineer in one convenient volume. The physical and thermodynamic properties of gases and their properties as fuels are discussed and tabulated. F.G.H.

Measurement of Radial Energy. Edited by W. E. Forsythe. McGraw-Hill Book Co., Inc., New York, 1937. 1st ed. 452 pp. Price $5.00. Reviewed in *Mech. Eng.*, **59** [9] 709 (1937).—Twenty-one specialists collaborated in preparing this book which is sponsored by the National Research Council. It contains a thorough compilation of useful information pertaining to radial energy and methods of measuring it. The treatment covers loss of radiation, radiation constants, care that should be taken with the source in radiation measurements, and methods of separating radiation into wavelength intervals. Methods of measurement are considered in the fields of radiometry, photometry, and pyrometry. Detailed bibliographies are included. F.G.H.

PATENT

Tunnel oven for ceramic products. Soc. des Fours Industriels et Métallurgiques. Brit. 503,613, April 26, 1939 (Oct. 9, 1936).

Geology

Andalusite in pegmatite from Fresno County, California. G. A. MacDonald and Richard Merriam. *Amer. Mineralogist*, **23**, 588–94 (1938).—The andalusite was developed by pneumatolytic action following the crystallization of the surrounding pegmatite. The aluminous vapors were of magmatic origin. Later, hydrothermal solutions attacked the andalusite and altered it in part to sericite. The optical and physical differences between the light and dark varieties of andalusite are due to the larger amount of ferric iron in the latter. F.J.Z.

Bentonite and the structure of gels. W. K. Lewis. *Can. Chem. & Process Industries*, **22** [2] 85 (1938).—The ultimate particles of bentonite are platy in shape and acidic in character with an equivalent weight which is approximately independent of particle size. Under proper conditions, their aqueous suspensions show unmistakable evidence of gelation at concentrations below 0.10% of clay. The setting time of a bentonite sol (conversion of sol to gel) is decreased greatly in certain cases by merely doubling the concentration of electrolytes, and also with decreasing size of the clay particles, with the age of the sol, and with temperature. Under conditions of viscous flow, clay suspensions show abnormally high viscosities and yield points, both greatly influenced by the concentration of the suspension, its history, and the nature of the suspending medium. The most plausible explanation of these characteristics is the assumption that the flow behavior of clay suspensions is due to the mechanical interference of the platy particles or of agglomerates of them. The behavior of many gel-forming systems (other than clay) is complicated by other factors. See *Ceram. Abs.*, **17** [3] 116–17 (1938). E.J.V.

Colloidal properties of refractory clays. L. Longchambon and J. Zajtman. *Arts du Feu*, **1** [6] 203–207 (1938).—French refractory clays are exclusively of the kaolinitic type. The behavior of colloidal particles is described. The adsorption of the OH anion and the subsequent fixation of cations is essential. The orientation of water around the particles increases the viscosity. F.E.V.

Concentrating raw materials for the silicate industry. I. N. Katschan. *Gorno-Obogatitel. Zhur.*, **2** [12] 20–24 (1937); abstracted in *Chem. Zentr.*, **1938, II**, 745.—K. discusses the characteristics and chemical composition of various raw materials, such as quartz sand, pegmatite, kyanite, and clay. Methods of concentration and purification and their suitability are dealt with. M.V.C.

Fluorescence of compounds containing manganese. J. T. Randall. *Proc. Roy. Soc.* [London], **A170**, 272–93 (1939).—R. investigated the fluorescence at low temperatures of a large number of compounds containing manganese. In the pure manganese halides, the red fluorescence is a property of all manganese atoms in the crystals, and the transitions are characteristic of the divalent ion Mn^{++}. With solids containing manganese only as an impurity (activator), the manganese may be entirely responsible for the fluorescence, the matrix lattice may contribute to the emission spectrum, or complex multiple impurities may be functioning. A.P.

Goldschmidtine, antimonide of silver. M. A. Peacock. *Amer. Mineralogist*, **24** [4] 227–41 (1939).—Chemical, physical, and optical properties of goldschmidtine are presented, and the newly recognized mineral is used to exemplify the method of determining the structural lattice from the crystal form by applying the harmonic-arithmetic rule to the gonomonic projection of the observed forms. F.J.Z.

History of the study of ore minerals. Ellis Thompson. *Amer. Mineralogist*, **24** [3] 137–54 (1939).—T. reviews the progress made in the study of ore minerals from the beginning of the last century up to the present. Developments include general methods, abrasive and polishing methods, chemical methods, mill products, quantitative macroscopic and microscopic analysis, technique, and X-ray methods. F.J.Z.

Lithium compounds in 1938. Anon. *Bull. Amer. Ceram. Soc.*, **18** [5] 186 (1939); see *Ceram. Abs.*, **17** [10] 340 (1938).

Mechanical units superior in sedimentation practice. Anon. *Can. Engr.*, **76** [12] 6–8 (1939).—Current methods of sedimentation are reviewed, and the advantages of continuous sludge removal are enumerated. B.L.

Mineralogical constituents of clays. H. Longchambon. *Arts du Feu*, **1** [5] 151–73 (1938).—The principal constituents are kaolinite, montmorillonite, sepiolite-palygorskite, and sericite-illite. Diffraction patterns are given, dehydration is described, and structural formulas are proposed. L. discusses the presence of minor constituents. Amorphous mixtures of silica and alumina gels (allophane) are without practical significance. The finest colloidal particles are crystalline. F.E.V.

Mississippi's subsoil is storehouse of valuable ceramic clays. Anon. *Ceram. Age*, **31** [6] 191–92 (1938).—The results of a statewide geological survey are briefly described. F.G.H.

Optical and X-ray methods in the study of clays. M. Mehmel. *Ber. Deut. Keram. Ges.*, **19** [8] 295–328 (1938).—A mixture of α monobromnaphthalene, paraldehyde, and cedarwood oil is recommended for determining the refractive index of clay particles. Dehydrating liquids such as glycerine must be avoided, as they may alter the index of montmorillonite and halloysite. The powder method of X-ray spectroscopy is described, and recent work on the structures of the clay minerals and other materials which might be present in clays is summarized. These methods, together with chemical analyses, make possible effective classification of clays for their various uses. E.J.V.

Petrography of South Victoria Land rocks. Duncan Stewart, Jr. *Amer. Mineralogist*, **24** [3] 155–61 (1939).—A petrographic quantitative study has been made of the mineral composition of certain igneous intrusive rocks of South Victoria Land, Antarctica, and comparisons are made between these rocks and those examined from other antarctic lands. F.J.Z.

Physical properties of clays. E. G. Richardson. Read before Pottery Section, British Ceramic Society, Jan., 1939; abstracted in *Brit. Clayworker*, **47** [562] 346 (1939). R.A.H.

Problems in clay research. K. Endell. *Ber. Deut. Keram. Ges.*, **19** [8] 328–31 (1938).—The remarkable plastic properties of bentonite are due to the large amount of water bound by its particles. It is preferable for clay because organic plasticizers burn away before their work is done, whereas bentonite forms a definite ceramic bond, even between relatively inert particles. E.J.V.

Pyrophyllite developments in North Carolina. W. A. Milliken. *Ceram. Age*, **31** [1] 18–19 (1938).—The mining and milling of pyrophyllite are briefly described. As a substitute for Cornwall stone in wall-tile bodies, pyrophyllite gives equal absorption, shrinkage, modulus of rupture, greater uniformity over the firing range, and lower moisture expansion. Illustrated. F.G.H.

Radioactivity, artificial and natural. K. K. Darrow. *Bell System Tech. Jour.*, **17** [2] 292–318 (1938).—The world as it was known before the days of transmutation was constructed of about 250 kinds of atoms, each consisting of a nucleus surrounded by a family of electrons. Most of these nuclei were stable and perpetual, but about 40 were unstable and doomed to perish in time, by ejecting either alpha particles or negative electrons. These were the natural radioactive bodies. To these 40 kinds of radioactive nuclei found in nature, physicists have added in four years 220 more by the art of transmutation. Every chemical element known to exist, with the exception of hydrogen, has at least one radioactive type of nucleus or isotope, and many have more than one. These radioactive nuclei are often made simply by adding neutrons to nuclei which already exist and are stable. There are, however, other and more complicated processes, in which neutrons, protons, deutrons, or alpha particles impinge on nuclei and seem to enter them, while other particles

leap out. Many radioactive bodies have been made in two or three different ways. H.E.S.

Synthesis of orthoclase and albite by pneumatolysis by means of disruptive explosives. A. MICHEL-LÉVY AND J. WYART. *Compt. Rend.*, **208** [4] 293–94 (1939).—A mixture of 0.12 g. precipitated silica, 0.4 g. alumina, and 0.9 g. potassium or sodium carbonate in 1.50 g. hexogen was exploded in an atmosphere of A; the explosion chamber was of Ag in the case of orthoclase and of Cu in the case of albite. The results of these experiments to create artificial feldspars confirm certain petrographic theories of the origin of the minerals. M.H.

PATENTS

Clay product and process of preparing. W. T. MALONEY (Georgia Kaolin Co.). U. S. 2,158,987, May 16, 1939 (Nov. 26, 1934).

Manufacturing salts by base exchange by means of zeolite. MAXENCE DRUJON. U. S. 2,155,477, April 25, 1939 (April 26, 1937).—Process for the simultaneous manufacture of alkaline metal salts and magnesium salts consists in dissolving calcined magnesium oxide in water charged with carbonic acid gas under pressure, passing the solution while maintaining the pressure over alkaline zeolite, and regenerating the zeolite to recover the magnesium salts.

Treatment of bauxite residues. A. P. LAURIE. Brit. 502,376, March 29, 1939 (Nov. 27, 1937).

Chemistry and Physics

Calcium arsenates. Study of the system As_2O_5–CaO–H_2O at 17°C. H. GUERIN. *Compt. Rend.*, **208** [13] 1016–1018 (1939).—The study established the following six arsenates and their p_H in solutions: $(AsO_4)_2CaH_4$ and $(AsO_4)_2Ca_2H_2 \cdot 2H_2O$, p_H 2; $(AsO_4)_2Ca_2H_2 \cdot 4H_2O$, p_H 6; $5As_2O_5 \cdot 5CaO \cdot 10H_2O$, p_H 6.8; $(AsO_4)_2Ca_2 \cdot xH_2O$, p_H 7.8; $As_2O_5 \cdot 4CaO \cdot 5H_2O$, p_H 9.6. The monocalcic arsenate is the most acid. The properties are compared with those of Ba arsenates. M.H.

Cobalt–manganese–aluminum system. W. KÖSTER AND E. BEGHARDT. *Z. Metallkunde*, **30** [9] 281–86 (1938).—Thermal analysis and structure observations of the partial system Co–Mn–MnAl–CoAl are presented. The curing temperature of the ferromagnetic α-solid solution was determined. Illustrated. C.H.R.

Cobalt–zinc system. J. SCHRAMM. *Z. Metallkunde*, **30** [1] 10–14 (1938).—The system was studied by X-ray, thermal, and microscopic methods. Alloys were made containing up to 55% Co. Liquidus lines were determined from 55% Co to pure zinc. Microscopic investigation showed that (1) the β phase has a small range· (2) the β_1 phase has a large solid solution range; the cobalt limits are at about 49.5% Co; and (3) the Γ solid solution has a large homogeneous range. Illustrated. C.H.R.

Cordierite. A. N. WINCHELL. *Amer. Mineralogist*, **22**, 1175–79 (1937).—W. prefers to use the molecular ratio between $FeO + 2Fe_2O_3 + MnO$ and $MgO + FeO + 2Fe_2O_3 + MnO$ in presenting results of a study of cordierite. Diagrams showing variations in composition and physical properties in cordierite and the relation between specific gravity and optical properties are presented and discussed. F.J.Z.

Cristobalite formation as a factor in freezing of pyrometric cones. PAUL LAURENS SMITH. *Jour. Amer. Ceram. Soc.*, **22** [6] 189–92 (1939).

Determination of specific surface of powders: II. P. C. CARMAN. *Jour. Soc. Chem. Ind.* [London], **58** [1] 1–7 (1939).—The technique of the method has been modified so that it is applicable to powders with an average particle size as low as 2 μ. The method is applied to zinc dust and to Portland cement, and particular attention is paid to the unsatisfactory nature of present methods with reference to Portland cement. G.R.S.

Diffusion of X-rays by crystals and microcrystallized bodies. A. GUINIER. *Compt. Rend.*, **208** [12] 894–96 (1939).—A photographic study of the diffusion of an X-ray beam on crystallized bodies, such as diamond, graphite, and Cu crystals, showed no discontinuities in the curve. The diffusion increases near the rays of diffraction and does not become zero at small angles of incidence of the X-rays; it decreases with the angle at first but later runs horizontally (parallel to the *X* axis). G. discusses discrepancies of these results with the theories of Debye and Compton and attempts to explain them. M.H.

Examination of the crystallography and other physicochemical properties of potassium lead copper hexanitrite. J. E. MACKENZIE AND R. L. SMITH. *Rec. Trav. Chim.*, **57** [11] 1211–17 (1938).—Goniometric measurements of $K_2PbCu(NO_2)_6$ and its preparation are described in detail The salt crystallizes in the cubic system class 32, cube (100), rhombic dodecahedron (110), triakisoctahedron (775). The refractive index could be determined only approximately to ≥ 1.8. Heating to 130° removes absorbed water; above 150° the salt disintegrates rapidly. M.H.

Partial range Mg-Al_3Mg_4-Mg_3Tl_2 of the three-component magnesium–aluminum–thallium system. W. KÖSTER AND E. WAGNER. *Z. Metallkunde*, **30** [9] 338–42 (1938).—The range of the three-phase equilibrium, determination of a four-phase field, boundry of the ternary magnesium solid solution field, hardening of ternary alloys with 10, 20, and 30% Tl, and the study of the corrosion resistance of such alloys are discussed. Illustrated. C.H.R.

Partial range Mg-$MgCd_3$-Mg_3Tl_2 of the three-component magnesium–cadmium–thallium system. W. KÖSTER AND E. WAGNER. *Z. Metallkunde*, **30** [9] 335–38 (1938).—The structure, hardening possibilities, and corrosion resistance of this portion of the system are discussed. Illustrated. C.H.R.

Properties of feldspathic glasses. B. LONG. *Arts du Feu*, **1** [4] 119–21 (1938).—Expansion and viscosity curves of true feldspathic glasses are given. Transformation and softening points are clearly determined. The effect of hardening is shown. F.E.V.

Quantitative analysis based on spectral energy. MORRIS SLAVIN. *Ind. Eng. Chem., Anal. Ed.*, **10** [8] 407–10 (1938).—The work described is part of a research program by the Nonmetals Division of the U. S. Bureau of Mines on the adaptation of quantitative methods of spectrochemical analysis to nonmetallic minerals. Illustrated. F.G.H.

Reactions in the solid state. W. E. GARNER. *Science Progress*, **33** [130] 209–29 (1938).—G. classifies reactions in the solid state as (1) those involving no crystallographic steps, (2) those involving one crystallization step, (3) those involving the destruction of the crystalline lattice, and (4) those which involve both the creation and destruction of lattices. The diffusion in solids, the creation and growth of nuclei, pressure-time curves, and the deflagration and detonation of solids are discussed. C.H.R.

Recovery of laboratory reagents. P. DICKENS. *Stahl & Eisen*, **58**, 1403–1406 (1938).—D. gives methods for the recovery of reagents used in steel analysis, *viz.*, ammonium molybdate, silver, mercury, iodine, and tin, and in the purification of mercury. L.R.B.

Solid reaction between magnesium oxide and titanium oxide. Y. TANAKA. *Bull. Chem. Soc. Japan*, pp. 212–18 (1939).—Mixtures of MgO and TiO_2 were heated at 1400°C for 10 hr. T. studied the compounds which are formed by solid reaction of MgO and TiO_2. He determined their specific gravities and solubilities and made X-ray and microscopic analyses. Results were as follows: (1) $2MgO \cdot TiO_2$, $MgO \cdot TiO_2$, and $MgO \cdot 2TiO_2$ were determined; (2) $2MgO \cdot TiO_2$ is soluble in 4 *N* hydrochloric acid, $MgO \cdot TiO_2$ is soluble in 12 *N* hydrochloric acid, and $MgO \cdot 2TiO_2$ is insoluble; (3) the crystal of $MgO \cdot TiO_2$ is

of the tetragonal system; its specific gravity is 3.52, and gitter constants are $a = 4.94$ Å, $c = 6.67$ Å; (4) a mixture containing $2MgO \cdot TiO_2$ sintered well. Y.K.

System CaO–CaF_2–Ca_2SiO_4. WILHELM EITEL. *Z. Angew. Mineral.*, **1**, 269–84 (1938); *Chem. Abs.*, **33**, 2403 (1939).—Forty melts of this system are described, and a phase diagram is constructed; several photomicrographs illustrate the effect of the presence of CaF_2.

System $NaAlSiO_4$–FeO–SiO_2. N. L. BOWEN. *Amer. Mineralogist*, **22**, 206 (1937).—In a system with the above components, fayalite and albite are binary compounds. The results of a study of mixtures of fayalite and albite have been published ("System—," *Ceram. Abs.*, **15** [10] 315 (1936)). The fayalite-albite line divides the general triangle into two parts. In one part there is a ternary eutectic between fayalite, albite, and silica, having a temperature of 980° and containing about 5% fayalite. In the other portion, there are certain complications due to the appearance of the oxide phases wustite and hercynate, but in the area where the phases do not appear there is a ternary eutectic between nepheline, albite, and fayalite having a temperature of 990° and containing about 10% fayalite. These mixtures are not unrelated to certain soda-rich rhyolites, trachytes, and phonolites, and the determinations throw some light on the genesis of such rocks. F.J.Z.

Systems of cobalt with boron, arsenic, zirconium, niobium, and tantalum. W. KÖSTER AND W. JULFINGER. *Z. Metallkunde*, **30** [9] 348–50 (1938).—Composition diagrams, the influence of these elements upon the conversion of cobalt, and hardening are discussed. Illustrated. C.H.R.

PATENTS

Process for the manufacture of silica gel. SOC. ANON. DES PRODUITS CHIMIQUES DE LAEKEN. Brit. 503,968, May 3, 1939 (Sept. 9, 1937).

Producing magnesium oxide from magnesium sulfate. WILHELM GENSECKE, KARL EBNER, AND OTTO REEH (Metallges. A.-G. and Vereinigte Kaliwerke Salzdetfurth A.-G.). Ger. 670,681, Jan. 5, 1939 (Oct. 8, 1936); IV*b*/-12*m*. 3.—A $MgSO_4$ solution is first treated with ammonia and then with both ammonia and sulfur dioxide; in separate reaction chambers, the successive precipitates, $Mg(OH)_2$ and $MgSO_3$, which have been removed from the solution, are thermotically decomposed. The SO_2 forming upon decomposition of the $MgSO_3$ is used again in the process. D.A.B.

General

Ceramic exhibits at Golden Gate International Exposition. ANON. *Bull. Amer. Ceram. Soc.*, **18** [5] 166–70 (1939).

Ceramics and cements. M. DUVOIR AND G. HAUSSER. *Arch. des maladies professionelles*, **2** [2] 157–68 (1939).—A ceramic worker employed by the N. R. Company for about two years as a pourer of ceramic paste had to stop work in Feb., 1938, on developing a severe case of secondary eczematous dermatitis, the so-called "bricklayer's itch." In May, 1938, he was awarded by the Court of the Dole half the wages his 30 days' absence had cost him. The Company appealed the case to the next higher Court of the Dole on the grounds that (1) the worker had not shown by medical certificate that his disease corresponded to one of those listed in the law of 1919 or that of Jan., 1931, relative to occupational diseases, and (2) he had not proved the necessary relation of cause and effect between his occupation and his skin disease but had based his claim entirely on the testimony of the medical expert attending him. In Nov., 1938, however, the next higher Court reaffirmed the judgment against the N. R. Company given in the previous hearings because (1) ceramic paste was legitimately a form of cement, largely because of the clays common to both (details are given), and (2) as such, it was capable of causing cement eczema and had actually caused the disease in the ceramic worker in question. In discussing this final verdict the authors describe thoroughly the history and composition of cements from the time of the Romans to the present; they review the skin diseases incident to working in cement materials, cite authorities, compare the eczematous lesions deriving from cements with those exhibited in the plaintiff, and admit considerable analogy quite justly, as had the higher Court. After a detailed review of ceramic materials, processes, and products, however, they conclude that neither in composition nor products could ceramics be correctly placed under cements. Lacking the skin tests which would have shown what substance or substances in the ceramic paste manipulated by the worker would or might have caused his skin condition, they remain neutral on the Court's statement that "incontestably" he had cement-worker's eczema or "bricklayer's itch." They summarize with brief comment, however, the chief occupational diseases of ceramic workers, *viz.*, silicosis (the most prevalent), lead intoxications, occupational deformities of the lower limbs, lesions of potters connected from time immemorial with the revolving turret, and some special troubles of Russian potters. Cutaneous diseases in the ceramic industry are dealt with separately. Cutaneous lesions are rare among ceramic workers and are generally due to some other cause than working with ceramic paste; hitherto, no such secondary eczematous dermatitis of the type of bricklayer's itch has been described for ceramic workers. Illustrated. K.R.

Efflorescence of ceramic products. A. SIMON. *Ber. Deut. Keram. Ges.*, **19** [8] 334–41 (1938).—When magnesium chloride, calcium chloride, or sodium chloride is added to clay, all the chlorine is lost on firing below 700°C, but the sulfur trioxide from sulfates is retained up to 1000°C. When free CaO is present, the SO_3 may be taken up from the kiln atmosphere between 500° and 800°C. Although $CaSO_4$, owing to its low solubility, does not readily effloresce, $MgSO_4$ is formed in the presence of MgO and passes freely to the surface with moisture. At firing temperatures, $BaSO_4$ reacts with calcium compounds to form $CaSO_4$; barium carbonate, therefore, provides no protection from efflorescence when calcium carbonate, etc., is present. E.J.V.

Engineer mixes economics with technologic work. ANON. *Science News Letter*, **34** [20] 311 (1938).—The president of Massachusetts Institute of Technology and a committee of the Engineers' Council for Professional Development compiled the following definition: "An engineer is one who, through application of his knowledge of mathematics, the physical and biological sciences, and economics, and with aid, further, from results obtained through observation, experiences, scientific discovery, and invention, so utilizes the materials and directs the forces of nature that they are made to operate to the benefit of society." An engineer differs from the technologist in that he must concern himself with the organizational, economic, and managerial aspects as well as the technical aspects of his work. P.G.H.

India and pottery. SACHIN ROY. *Indian Ceramics*, **1** [1] 17–20 (1938).—The history of the modern ceramic industry in India is sketched with figures on imports of porcelain and earthenware for the last 12 years. A.P.S.

Influence of general lighting on machine-shop tasks. SHARP AND CROUCH. *Trans. Illum. Eng. Soc.* [N. Y.], **34** [3] 271–95 (1939).—The effects of nine systems of general lighting in common use today are analyzed in regard to (1) the revealing quality of the illumination on the task, (2) objectionable glare from objects, and (3) objectionable direct component toward the eyes of the worker. All systems fail in properly revealing detail, give rise to high lights of objectionable brightness, and cause reduction in seeing ability due to direct light flux toward the eyes of the worker. H.K.R.

Metabolism of patients suffering from silicosis. A. BÖHME. *Arch. Gewerbepath. & Gewerbehyg.*, **8**, 449–57

(1938).—To determine whether silicosis with its severe lung changes impairs the basal metabolism of the silicotic during work, it is first necessary to determine his basal metabolism when at rest. B. reports the results derived from metabolism estimates of 27 patients with silicosis, none of whom had any tubercular complication. Knipping's apparatus was used for the tests which were made under the usual conditions: in the morning after long rest, the patient fasting, and after a preliminary examination. Most of the subjects showed metabolism values 10 to 15% higher than those of normal persons. Patients with severe silicosis whose working capacity was reduced 50 to 80% by their disease often showed a rest-fasting metabolic value of 100 to 110%. Greater rises were generally traceable to a disproportionate ventilation of the lungs, expressed in respiratory count, minute volume, and respiratory equivalents. These rises were sometimes voluntary and sometimes due to mental excitement. In some severe cases, increases shown by metabolism tests were of serious import, the lung ventilation figures not having risen. Difficulty in moving the fixed thorax was partly responsible, calling for increased activity of the respiratory muscles; the shortness of breath (dyspnoea) was often accompanied by increased tension of the bodily muscles. B. gives six tabulations, with explanatory comment, often upon individual cases. Sixteen patients with light and average silicosis are detailed for age, vital capacity, respiratory count, minute volume, respiratory equivalent, rise in metabolism, and respiratory quotient. Rest in these cases gave a normal metabolism. The relation between the rest metabolism and respiratory frequency of 13 entirely sound people is shown. The test results for 21 severe silicosis cases, some of whom had heart insufficiency or other evidences of advanced disease and thus showed the highest metabolism increases, are given. B.'s comments are interspersed with results or conclusions of other experts concerned with these problems. See "Recovery —," *Ceram. Abs.*, **18** [1] 39 (1939). K.R.

Mining and milling operations of the Canadian Johns-Manville Co., Ltd., at Asbestos, P. Q. R. C. Rowe. *Can. Mining Jour.*, **60** [4] 185–213 (1939).—R. describes the mining, milling, and manufacturing methods. G.M.H.

New verified theory of lateral earth pressures. *Can. Engr.*, **76** [10] 10–11 (1939).—The classic theories of Coulomb and Rankine have been discarded because of their limited application. Research has disclosed that the maximum intensity of pressure from buildings and earth is at the surface, diminishing rapidly with depth. The lateral pressure problem is resolved into a consideration of three phases: (1) the pressure of the retained material on a wall so rigid that it will move only an amount so small as not to permit a fracture of the bank retained; (2) the pressure on a wall when the movement is sufficient to permit a fracture of the bank retained; and (3) pressures induced upon a wall by additional loadings applied on the surface of the bank retained. The general form of expression developed for lateral pressure against a sheeted cut is $F = Kwy$, where F = total lateral pressure, K = constant or hydrostatic pressure, w = load per unit volume, and y = the deflection. K may vary as much as 300%. The new theory makes possible great economies in construction. B.L.

Peak-load problem in industrial steam plant; steam and hot-water storage. E. G. Ritchie. *Jour. Inst. Fuel*, **11** [58] 357–70 (1938).—Adaptability of a thermal storage system to meet the needs of the consumer is of much greater importance as an economic factor than is the attempt to extract from the coal its last quota of heat. H.E.S.

Powdered fuel firing. T. F. Hurley and R. Cook. *Jour. Inst. Fuel*, **11** [57] 195–208 (1938).—Large combustion chambers are no longer essential in order to secure good combustion. Their size can not be reduced without encountering operating difficulties arising from the molten ash particles being carried out of the furnace by the flue gases. The fundamental reason for this is the small ratio of surface to volume in large chambers. A detailed description is given of two burners designed for rapid ignition and controlled mixing of the fuel and air, thus obtaining high-heat release combined with good efficiency. H.E.S.

Production of dust in hard headings and means for its suppression. J. Ivon Graham, D. G. Skinner, and W. H. Walton. *Colliery Guardian*, **158**, 385–87 (1939).—A mist projector used after blasting reduced the amount of dust, but the reduction varied in different mines. After an explosion dispersed shale dust in a test gallery, water mist reduced the average dust concentration, taken over a period of 5 min., by 76%. The addition of a wetting agent reduced the peak amount of the dust but not the time for complete elimination. Dry drilling in one mine showed thirty times as much dust as wet drilling. When loading cars, the konimeter showed a variation of 660 to 4000 particles/cc. W.D.F.

Rate of production and free silica content of the fine dust produced by rock drilling. A. Shaw and J. Ivon Graham. *Colliery Guardian*, **158**, 326–28 (1939).—Large pieces of rock were drilled in the laboratory with holes 6 in. deep, and dust finer than 6.2 microns was collected by suction from above. Analysis of the dust showed that the free SiO_2 in it was always less than that in the rock. In a hard conglomerate, the difference was small (76% and 74%), but in a soft sandstone, the difference was much greater (80% and 56%). Dust production ranged from 1.92 to 4.97 g./min. and 1.3 to 10.2 g./ft. drilled. As some of the fine dust was carried down by the coarse cuttings, another method was tried that collected the coarse cuttings and separated the fines by suction. The total amount of dust less than 5 microns in size varied from 35 to 128 g./ft. drilled, and the free SiO_2 varied from 10 to 119 g./ft. drilled. Konimeter tests on dust from some of the more siliceous rocks showed counts from 3 to 24 thousand particles/cc. There is a small but definite increase in the free SiO_2 content of the dust with a decrease in the rate of drilling. Drilling rates on a quartzite of 3.3 and 2.5 in./min. gave, respectively, 81% and 84% free SiO_2 in the dust. Rocks which form more than 25 g./ft. of free SiO_2 dust (0 to 5 microns) should be considered harmful. W.D.F.

Recommended practice of industrial lighting. Anon. *Trans. Illum. Eng. Soc.* [N. Y.], **34** [4] 369–410 (1939).—This restatement of results amounts in some cases to a revision of former codes to take care of the present-day trends in lighting practices. The subject is discussed under the following headings: (1) *Advantages of good illumination*, including the effect of light on accuracy of workmanship, increased production, better utilization of floor space in the plant, cleanliness, better seeing ability and less eye strain among employees, and fewer accidents; (2) *Factors of good illumination:* (*a*) quality of lighting such as glare, distribution color quality, and the color of surroundings, and (*b*) quantity of light. Recommended minimum standards of illumination are given under which clay products, enameling, and glassworking operations are mentioned in detail. Automatic photoelectric control of lighting systems for natural lighting is discussed, and methods of artificial lighting such as direct, semidirect, indirect, and supplementary, are noted in detail. Adequate wiring is also discussed. H.K.R.

Research. F. H. Clayton. *Chem. Age* [London], **40**, 365 (1939).—The amount spent on research in the British Isles is surprisingly small. The total expenditure, both public and private (including estimated individual research), is less than $^1/_4$ d for every pound sterling of the national income, but the total estimated annual return for this expenditure is about 800% or 2 d per pound per annum. A.B.S.

Safety rewards progressive industries. Harry L. Sain. *Ceram. Age*, **33** [2] 54–55, 57 (1939).—Safety programs for ceramic industries are emphasized. F.G.H.

Silicosis and its prevention. J. S. Haldane, F. Haynes, A. Shaw, and J. Ivon Graham. *Colliery Guardian*, **158**, 367–70 (1939).—The diagnosis of silicosis is extremely difficult apart from a history showing prolonged and intense exposure to a dust with a high concentration of free silica.

Some cases diagnosed as silicosis in South Wales are probably a variety of bronchitis, as there was little or no exposure to siliceous dusts. Silicosis in coal miners is usually associated with work in a siliceous rock. Preventive methods include drilling with water or foam or dry drilling with a dust trap. Dust after blasting is best controlled with a water mist. The addition of a wetting agent should help. When siliceous rock is being loaded it should be kept wet by a spray. W.D.F.

Silicosis; a review of recent researches. J. ROBERTS. *Colliery Eng.*, **15**, 290–92 (1938).—The works of T. D. Jones and associates, W. R. Jones, A. H. Cox and A. Brammall, and J. G. C. Leech are compared. R. points out that the observation of W. R. Jones that sericite is present in some silicotic lungs can be linked up with the occurrence of silicosis among South Wales and, perhaps, Pennsylvania anthracite miners, as both anthracite and sericite are the products of dynamic metamorphism and occur together. L.R.B.

Solubility of quartz and silicates. C. C. LUCAS AND M. E. DOLAN. *Can. Med. Assn. Jour.*, **40**, 126–34 (1939); *Chem. Abs.*, **33**, 2394 (1939).—Solubility experiments with quartz (98.5% SiO_2) in very fine powder showed that blood serum, urine, water, and salt solutions leach small quantities of SiO_2 from quartz. This leaching is of impurities and gives an apparent solubility greater than the real solubility of the quartz.

Steel-string concrete according to Hoyer. H. AMOS. *Z. Ver. Deut. Ing.*, **83** [11] 337–38 (1939).—A. describes a new type of reinforced concrete in which the reinforcing material consists of steel wires up to 2 mm. with a tensile strength of about 26,000 kg./cm.^{2} and an elastic limit of about 24,000 kg./cm.^{2} The wires are stretched, before the concrete is poured, to a stress of 12,000 kg./cm.^{2} To counteract the reduction of the prestressing by the shrinking of the concrete, the wires are stretched first to 14,000 to 15,000 kg./cm.^{2} The wires are located longitudinally in the beam of concrete; lengths of 100 m. can be made and later subdivided without effect on the strength of the shorter pieces. A curve shows the total load supported by such a beam and the sag as a function of the prestress in the wires up to fracture. While a load of 5000 kg. with 12,000-kg. prestress has a sag of 60 mm. and breaks at 90 mm. sag (5200 kg. load), the same sag with 4000 kg. prestressed wires takes place at 3800 kg. total load; fracture occurs at 5000 kg. and 105 mm. sag. The effect of wire diameter and quality of concrete is discussed briefly. The saving in steel as compared with a steel beam of equal bearing load is about 97% and compared with the usual reinforced concrete, 90%. M.H.

BOOKS AND SEPARATE PUBLICATIONS

Ceramic Trade Directory, 1938. Ceramics Publishing Co., Inc., Newark, N. J., 1938. 248 pp. Price $6.00. Reviewed in *Ceram. Age*, **32** [5] 153 (1938).—Complete and accurate information on potteries in the U. S. and Canada is presented, including plants producing general ware, vitrified chinaware, electrical porcelain, floor and wall tile, sanitary ware, stoneware, abrasive materials, and terra cotta. The data cover plant location, character of ware produced, kiln capacity, names of company officials and titles, and other pertinent information. Sections devoted to ceramic schools and colleges and technical and trade associations are also included. F.G.H.

Engineering Thermodynamics. N. C. EBAUGH. D. Van Nostrand Co., New York, 1937. 208 pp. Price $2.85. Reviewed in *Mech. Eng.*, **59** [8] 631 (1937). F.G.H.

Fundamentals of Mine Haulage. D. L. MCELROY. *Bull. Virginia Polytech. Inst., Eng. Extension Div. Ser.*, No. 36, 16 pp. (1939).—The following essentials of safe and efficient mine haulage systems are discussed in the order given: (1) concentration (greatest production from smallest working area), (2) track, (3) haulage rolling stock, (4) haulage labor, (5) dispatching, (6) power, (7) safety, and (8) supervision of haulage. Illustrated. P.S.D.

German Grammar for Chemists and Other Science Students. JOHN T. FOTOS AND JOHN L. BRAY. John Wiley & Sons, Inc., New York, 1938. 323 pp. Price $2.25. Reviewed in *Metals & Alloys*, **10** [2] MA 122 (1939).—This book was prepared primarily for the student of science and technology who is interested in acquiring a reading knowledge of German books and periodicals. With the increasing pressure of other subjects, students of chemistry and metallurgy can not afford two or three years to obtain a reading knowledge of technical German, a necessity for the chemist, metallurgist, or metallurgical engineer who wishes to keep in touch with developments. The book will prove valuable to those who must acquire a reading knowledge of technical German, but will also prove of value to those who feel they already have acquired this reading knowledge.

Introduction to Modern Thermodynamical Principles. A. R. UBBELOHDE. Clarendon Press, Oxford, England; Oxford University Press, New York, 1937. 131 pp. Price $3.00. Reviewed in *Mech. Eng.*, **59** [8] 632 (1937). F.G.H.

Photometric Method for Making Dust Determinations. JOHN F. CADDEN AND EDMOND T. ROETMAN. *West Va. State Dept. Health Rept.*, 7 pp. (Feb., 1939).

Pocket Dictionary of All Technologies and Their Auxiliary Sciences (Handwörterbuch der Gesamten Technik und Ihrer Hilfswissenschaften). R. KOCH AND O. KIENZLE. Deutsche Verlags-Anstalt, Stuttgart and Berlin, 1935. Vol. I, 718 pp.; Vol. II, 788 pp. Price 72 Rm. Reviewed in *Mech. Eng.*, **59** [1] 50 (1937).—An excellent dictionary of engineering and technology is provided. The definitions are clear and extensive enough for ordinary needs. The work may be recommended to all who need a dictionary of general technical terms. F.G.H.

Sprechsaal Yearbook, 1939 (Sprechsaal-Kalender, 1939). Verlag Sprechsaal, Müller and Schmidt, Coburg, Germany. 428 pp. Price 2.50 Rm. Reviewed in *Brit. Clayworker*, **47** [563] 387 (1939).—Information contained in the book in previous editions is apparently not extended. An introductory chapter concerning the Four-Year Plan for the ceramic industry contains a criticism of the Western democracies. See *Ceram. Abs.*, **17** [4] 166 (1983). R.A.H.

Textbook of Thermodynamics. P. S. EPSTEIN. John Wiley & Sons, Inc., New York, 1937. 406 pp. Price $5.00. Reviewed in *Mech. Eng.*, **59** [10] 785 (1937). F.G.H.

Thermodynamics. J. E. EMSWILER. McGraw-Hill Book Co., New York, 1937. 4th ed. 351 pp. Price $3.00. Reviewed in *Mech. Eng.*, **59** [4] 299 (1937); *Power*, **81** [7] 411 (1937). F.G.H.

Thermodynamics. H. A. EVERETT. D. Van Nostrand Co., New York, 1937. 430 pp. Price $3.75. Reviewed in *Mech. Eng.*, **59** [12] 967 (1937). F.G.H.

Thermodynamics. S. E. WINSTON. American Technical Society, Chicago, 1937. 178 pp. Price $1.50. Reviewed in *Mech. Eng.*, **59** [4] 299 (1937); *Power*, **81** [4] 231 (1937). F.G.H.

Thermodynamics for Engineers. HENRY F. GAUSS. Edwards Bros., Inc., Ann Arbor, Mich., 1936. 426 pp. Price $6.30. Reviewed in *Mech. Eng.*, **59** [6] 460 (1937). F.G.H.

PATENTS

Manufacturing porous articles of clay. AAGE NIELSEN. U. S. 2,151,932, March 28, 1939 (June 8, 1931; renewed Sept. 21, 1934).—A process for the manufacture of porous ceramic articles of argillaceous materials consists in first adding deflocculants to a stiff plastic mass of clay, then making the thus produced fluid mass porous by incorporating gases therein, and finally adding flocculants to the porous fluid mass and molding the thus produced restiffened porous mass in a known manner.

Molded ceramic articles. JULIUS PINTSCH KOMMANDITGES. Fr. 831,576, Sept. 8, 1938; *Chem. Abs.*, **33**, 1901 (1939).—The binder used is an organic compound (liquid or solution) of Al, particularly an organic salt, *e.g.*, Al formate, bioxalate, tartrate, acetotartrate, or lactate.

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